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Pipe Down

WHEN navy boys are "on the loose" and things get exciting, appearance of a superior officer brings the familiar call. Synonyms in other jargons are "Cheese it," "Button up" and "Hissst."

The view above is not of a navy gun, big or otherwise, coming upon the roistering navy boys. It's a seagoing pipe line getting ready for launching,—a sort of pipe-line shipyard. Rather a new idea in shipyards, 3000 ft. long by 2 ft. wide, but most shipyards are not intended to build seagoing pipe lines. Queer submarine that; 3000 ft. long by 16 in. diameter. The answer is —Oil.

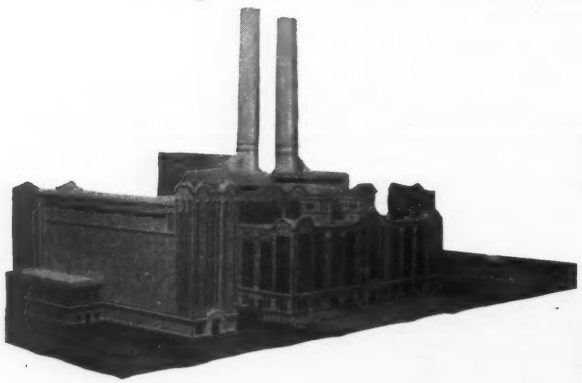
Down 70 mi. from Kettleman Hills to Estero Bay in a 10-in. line, oxy-acetylene welded into one piece, the oil comes at 1000 lb. pressure. Where to go? Tankers can anchor only at 3000 ft. off shore. Here comes in the submarine. Built in one welded section on a special narrow gage railroad, run 3000 ft. back into the hills on a 2 per cent grade, the submarine pipe moved forward on trucks as it was joined up, to its launching. Completed and the end capped, out it went by tug power to the tanker anchorage.

Like some other submarines, its final resting place is on the bottom of the sea. No more private-car parties. It is piped down for keeps.

That is just one kind of tool used for materials handling; on page 383 of this issue, Mr. Sayers tells about others that have more general application in power plants.

WHEN is an insulator not an insulator? This sounds like some of the old riddles we had propounded to us when we were young. The answer to most of those depended on some play on words, but in this case it is different. The answer to this one is, "when it is thyrite." Thyrite is a new material which is an insulator sometimes but not at others—it suits the desires of the electric current, so to speak. On page 389 you can find out what this is all about.

THE JAMES H. REED STATION



will help

Duquesne Light Co.

serve

Pittsburgh District

FIRST 60,000-KW. TURBO-GENERATOR AND 3—31,795-SQ. FT., 400-LB. BOILERS WILL SOON BE IN SERVICE. THIS IS THE FIRST UNIT OF A STATION WITH AN ULTIMATE CAPACITY OF AT LEAST 240,000 KW.

ON JULY 30, 1930, the James H. Reed Station of the Duquesne Light Co., a subsidiary of the Philadelphia Co., will officially be placed in service. Named for the late Judge James H. Reed, for a quarter of a century either president or senior vice-president of the Philadelphia Co., a unit of the Standard Gas & Electric Co. system, construction of the station was started at a ceremony held October 30, 1928, when Senator David A. Reed, a son of the man for whom the station was named, turned the first shovelful of earth.

Located on Brunot Island in the Ohio River about 2 mi. below Pittsburgh, the first section of the new station, designed and constructed by the Byllesby Engineering and Management Corp., will be built for two 60,000-kw. machines, only one of which will be installed at present, the second unit to follow as load conditions dictate. The ultimate capacity of the station will be at least 240,000 kw., probably made up of four 60,000-kw. units and 12—31,795-sq. ft., 400-lb. 735-deg. F. boilers. Design of the station and building space will permit expansion beyond this as needed.

Ample cooling water, facilities for receiving coal by rail and water, large coal storage facilities and close proximity to the dense load area of the Pittsburgh district make the 165-a. Brunot Island an ideal site for the new station. As shown on the map, Fig. 1, the James H. Reed station is immediately south of the old Brunot Island station and adjacent to the New Brunot Island switch house, Fig. 12, built in 1928 in advance of the generating station.

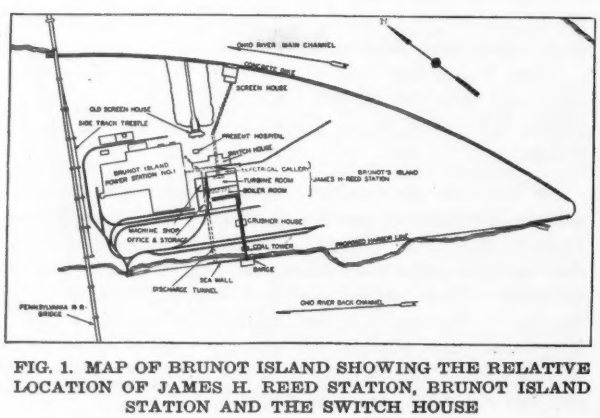


FIG. 1. MAP OF BRUNOT ISLAND SHOWING THE RELATIVE LOCATION OF JAMES H. REED STATION, BRUNOT ISLAND STATION AND THE SWITCH HOUSE

Although interconnected with the West Penn Power Co. at the north and with the Penn-Ohio Co., at the west, Colfax Station has been the main power supply of the Duquesne Light Co. system for the past few years. Rapidly growing load conditions made additional generating capacity imperative and because of the many advantages of space and location, a new station, rather than an extension to Colfax Station, was considered advisable.

MANY INNOVATIONS IN DESIGN

In general following more or less conservative practice, some of the features of the station are not only new but distinctive enough to make the station stand out as a decided advance in power station design.

Perhaps the most radical departure from accepted practice is found in the electrical auxiliary supply system, although the refinement in coal handling, storage and reclaiming, the car elevator, screen house, water treating equipment and storage facilities, the absence of open or deaerating heaters in the heat balance layout, and the heating system evaporator are all features which raise the station far above the average.

Details of all these various features cannot be included in a general article of this nature but will be covered in subsequent articles dealing with specific parts of the design.

Reed station is of brick, tile and concrete construction with a steel frame supported on concrete piles. Although not yet completed, an idea of the general appearance of this and surrounding structures can be obtained from the headpiece; Fig. 12, a sketch of the switch house and Fig. 9, a recent photograph showing the new station with the switch house on the left and

the old station on the right. The architectural treatment of the switch house is one of the outstanding examples of power station architecture in this country. The headpiece is a photograph an uncompleted ⅛ in. to the foot model made by Emil Kirtz.

As shown in Fig. 6, the 60,000-kw., 0.8 power factor, 1800-r.p.m., 11,600-v. 3-phase, 60-cycle, Westinghouse turbine generator, receiving steam at 375 lb., 735 deg. F., total temperature and bled at three points, will be set with its axis longitudinal with the turbine room and will be supplied with steam by three 31,795-sq. ft., 3-pass Stirling boilers, built with Kellogg hammer

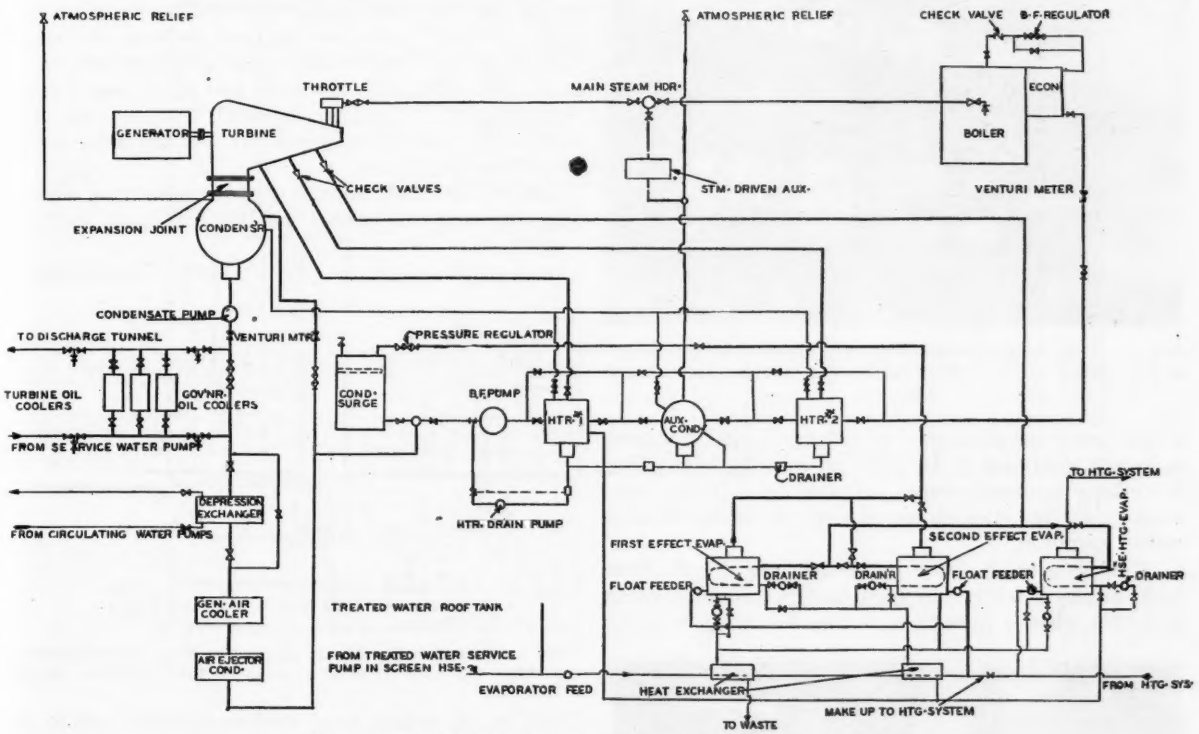


FIG. 2. FLOW DIAGRAM OF THE JAMES H. REED STATION

welded drums. These boilers are designed for a maximum working pressure of 448 lb. per sq. in. Later, three more boilers will be installed to serve unit No. 2.

The turbine is set over a Westinghouse 55,000-sq.ft., single pass, divided water box surface condenser with 10,000, ⅞-in., O.D., 24-ft. Admiralty tubes. The condenser will be mounted rigidly with a Phillips expansion joint between the turbine exhaust and condenser shell. The air ejector unit consists of three sets of three-stage ejectors, connected to common inter and after condenser. Two sets are sufficient for full load operation and the entire unit is located on a mezzanine floor just below the operating floor of the turbine room.

Duplicate turbine-driven hotwell and motor-driven Westinghouse circulating pumps will be used. The former rated at 1120 g.p.m. each, against a discharge head of 177 ft. are driven by 75-hp., 960-r.p.m. turbines, the latter of the vertical propeller type, are rated at 40,000 g.p.m. each against a 19-ft. head and are driven by 350-hp., 588-r.p.m. motors.

Direct-connected 250-v., 200-kw. exciters and pilot exciters will be used on each of the main units and a 400-kw. steam-driven exciter and pilot exciter provided standby service.

Three Cameron, four-stage turbine-driven, 565-lb. pressure feed pumps will be used; two rated at 1800 g.p.m. each and driven by 800-hp., 2100-r.p.m. turbines, are included for normal service, the third, rated at 600 g.p.m. and driven by a 300-hp., 2700-r.p.m. turbine, is intended for light loads.

Both forced and induced draft fans are driven by two speed motors, two Buffalo fans of each type for each boiler. Fans are designed to carry the normal load of 275,000 lb. of steam per hour on low speed, high speed being used for peaks up to the maximum load of 350,000 lb. per hr.

Forced draft fans, located on a mezzanine floor below the main firing aisle, are each designed for a maximum capacity of 63,300 c.f.m. of air against a 6-in. static pressure. They are driven by 1200/900-r.p.m., 125-hp. induction motors.

Square Corners Used for Breechings

Induced draft fans are designed for a maximum capacity of 127,000 c.f.m., 400 deg. F., gases at 6 in. static pressure. They are driven by 1200/900 r.p.m., 200-hp., induction motors. They are located directly below the economizer and because of the high outlet velocity are fitted with a special Venturi discharge section. One of the interesting features of the breeching design is the absence of formed bends, all such bends being made with square corners in which are incorporated guide vanes to reduce the pressure losses.

Details of the boiler and setting are shown in Fig. 10. Each boiler is fired by a Westinghouse, 18-retort, underfeed stoker with an undulating overfeed section,

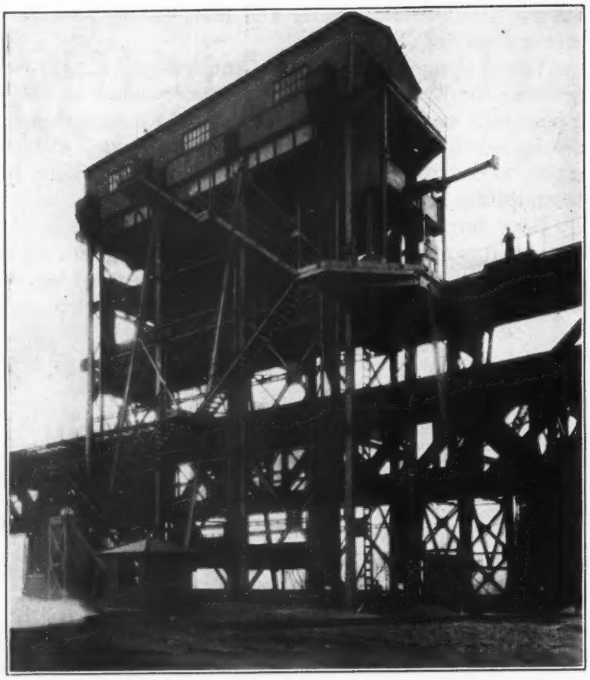


FIG. 3. CAR ELEVATOR USED TO LOWER CARS SOME FORTY FEET FROM THE PENNSYLVANIA TRACKS TO THE ISLAND

a total projected grate area of 585 sq. ft. and designed to burn a maximum of 44,000 lb. of coal per hour. The Waterbury hydraulic drive, actuated by a 50-hp., constant speed, induction motor, will give unusually flexible stoker operation.

Clinker grinders, two per boiler, are driven from both ends by 7½-hp., four-speed motors, provision being made for what is thought to be the first time, to carry

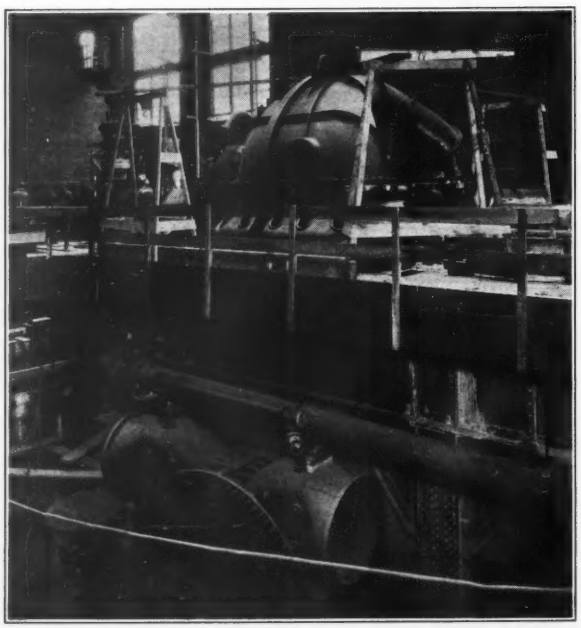


FIG. 4. THE TURBINE AND CONDENSER DURING ERECTION THE EARLY PART OF FEBRUARY. THE SMALL PIPE ACROSS THE TOP OF THE CONDENSER WATER BOX IS PART OF THE PRIMING SYSTEM

the water level for quenching in the ash pit, up to the center line of the grinding rolls. Ash is handled by a Hydro-Jet system and siftings from the overfeed section of the stoker, last pass of the boiler and from the economizer are piped directly to the sluice. Water for sluicing will be taken from the condenser discharge tunnel. Two vertical ash pumps driven by 150-hp., 690-r.p.m. motors are installed and are of sufficient size to care for eight boilers.

A furnace volume of 15,300 cu. ft. is provided, giving a ratio of 0.48 cu. ft. per sq. ft. of boiler heating surface and a heat release of 23,000 B.t.u. per cu. ft. at normal rating. All four walls are partially covered by Bailey cast-iron faced blocks, the remaining portion consisting of high refractory tile laid between the water wall tubes. The total water-cooled surface of 3230 sq. ft. made up as follows: side walls 500 sq. ft. each; front wall, 607 sq. ft. and bridge wall, 1623 sq. ft. The water-cooled side walls extend two feet above the center line of the mud drum.

Boilers are cross baffled for three passes with convection superheaters located in the first pass and the

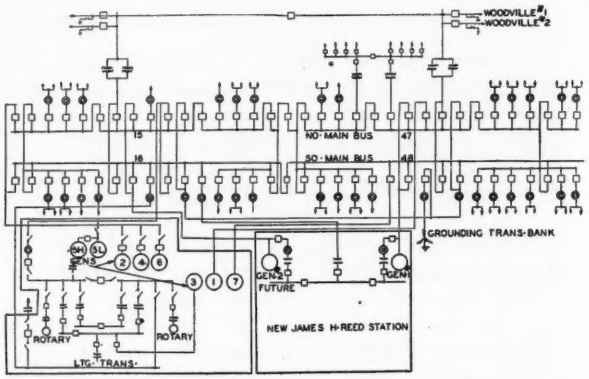


FIG. 5. WIRING DIAGRAM SHOWING THE CONNECTIONS OF THE OLD AND NEW STATIONS IN THE SWITCH HOUSE

13,572-sq. ft. return bend steel economizers behind the boilers as shown in Fig. 10. Alternate tubes in the first row are bent so as to form a slag screen which would approximate, in a straight tube design, omission of alternate tubes in the first row, omission of the second row and omission of alternate tubes in the third row. Each set of three boilers will be served by a lined steel stack, 20 ft. in dia. and 225 ft. high above the grates. Individual stoker hoppers will be fed by four spouts provided with Coal Spout Oscillator Co.'s spout swingers.

Diamond soot blowers will be used on both boiler and economizer, 14 elements on the former and four on the latter. Leeds & Northrup combustion control, Copes feedwater and excess pressure regulators and Venturi meters are also used.

Circulating pumps are located in a screen house on the river bank shown in the section, Fig. 8. Chain Belt Co. traveling screens are installed and the circulating water pumped through a 72-in. cast-iron pipe to the power house intake tunnels, which pass under the switch house, and into the turbine room as shown in the plan Fig. 6. Flow from the condenser is direct to the discharge tunnel which leads to the back channel of the river on the opposite side of the island from the screen house.

THE JAMES H. REED POWER STATION

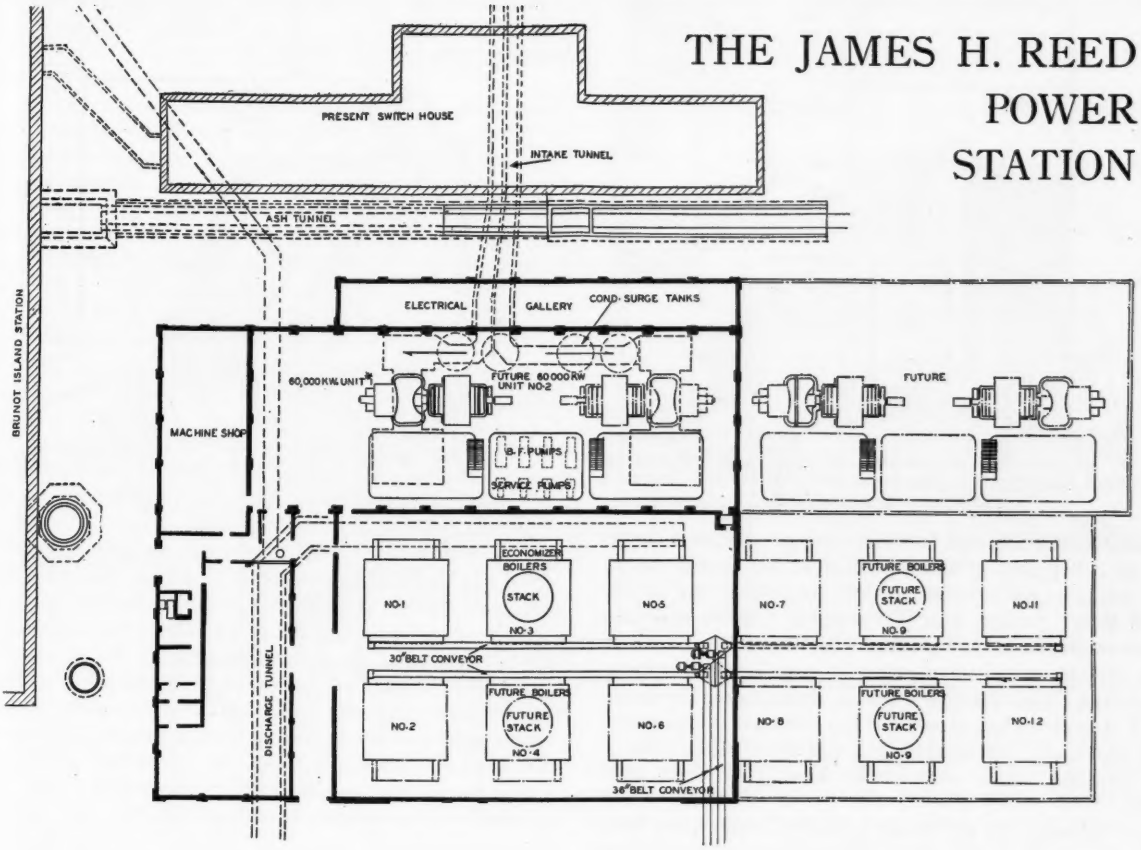


FIG. 6. PLAN OF THE STATION SHOWING THE ULTIMATE CAPACITY OF FOUR 60,000-KW. UNITS.

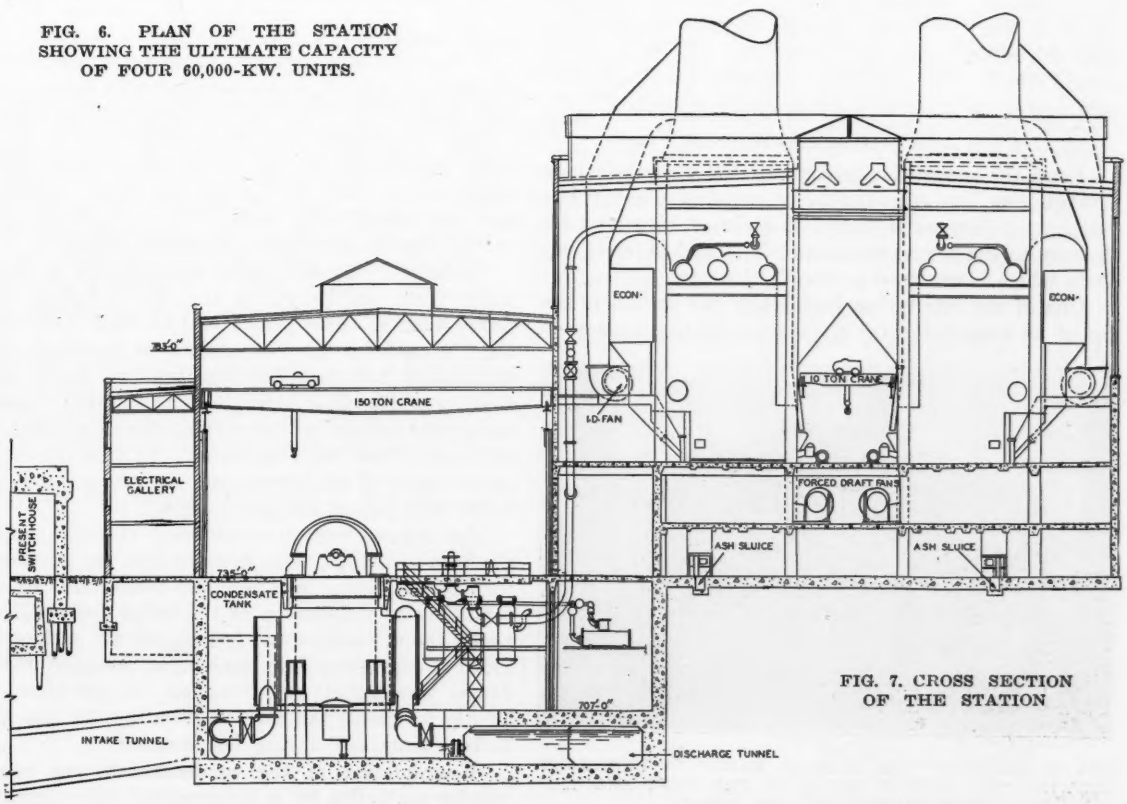


FIG. 7. CROSS SECTION OF THE STATION

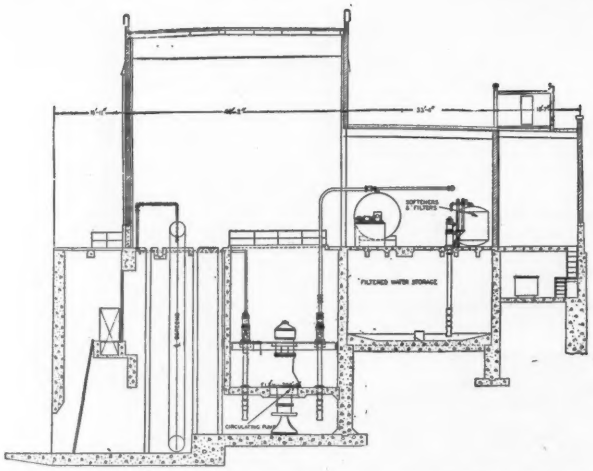


FIG. 8. SECTIONAL DRAWING OF THE SCREEN HOUSE SHOWING THE CIRCULATING WATER PUMPS AND WATER TREATING EQUIPMENT

Water filtering and treating equipment with a capacity of 200 g.p.m. is also installed in the screen house. All pumps used in this system, including the screen wash water pumps, are Worthington Coniflo verticals. River water is pumped through the Permutit sand filters to a 300,000-gal. filtered water storage below the treating tanks. This filtered water is then pumped through the Permutit zeolite tanks and the softened water stored in a 20,000-gal. overhead tank in the boiler room. Water for drinking, toilets and showers is supplied from deep wells.

All makeup for the boiler system is evaporated by a Croll-Reynolds evaporator, using steam from the first bleed point at a pressure of about 156 lb. abs. Although piped so that they may be used as two single effect evaporators, in normal operation they will be operated double effect. The auxiliary condenser (medium pressure heater) is used as the evaporator condenser.

No Open or Deaerating Heaters Used

From the evaporator feed pump, the water will pass through two heat exchangers to the first effect. The first heat exchanger is the shell drain or blowdown on the way to the sewer, the second heat exchanger is coil drain which is returned to the No. 1 heater.

One of the interesting features of the station is the use of an evaporator for the station heating system to guard against oxygen in the feedwater supply from air leaks in the heating system. This evaporator, shown at the right of Fig. 2, is also supplied with steam from the first bleed point, although a high-pressure steam connection is provided for use during periods when the main unit might be out of service. Vapor from the evaporator is used for heating the plant, screen house and coal towers, unit heaters being employed in place of radiators in all except the smallest offices.

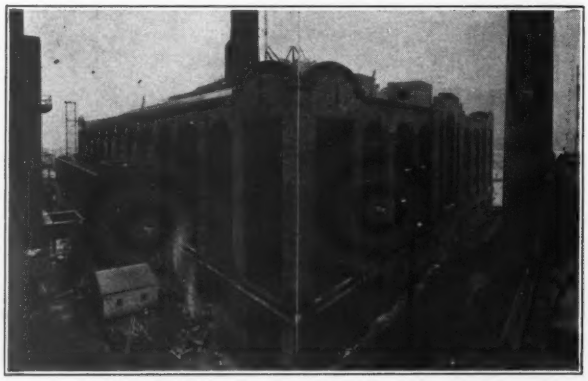


FIG. 9. VIEW OF THE STATION EARLY IN FEBRUARY SHOWING THE SWITCH HOUSE ON THE LEFT AND THE OLD STATION ON THE RIGHT

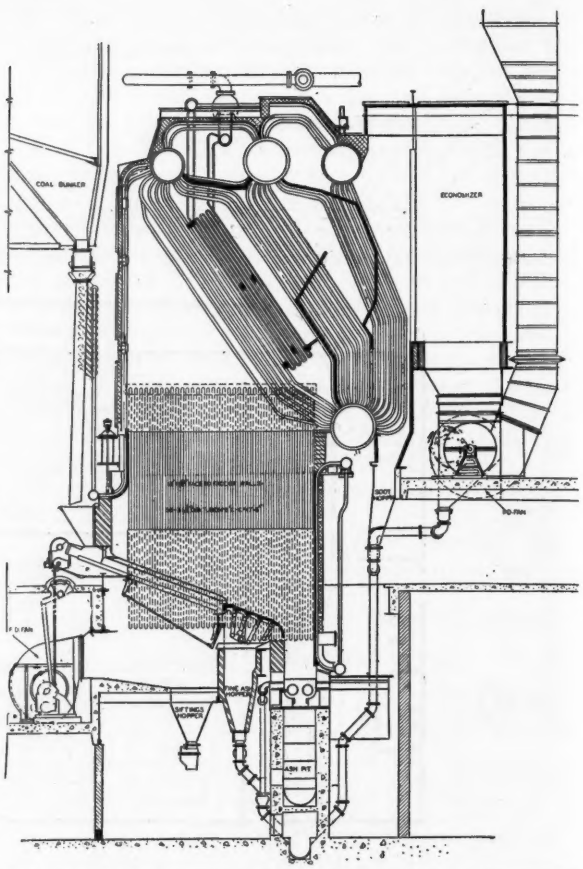


FIG. 10. EACH BOILER IS DESIGNED FOR A MAXIMUM OUTPUT OF 350,000 LB. OF STEAM PER HOUR

Details of the equipment arrangement in diagrammatic form are shown in the flow diagram, Fig. 2. Steam bled at three points at 13.7, 68.8, and 156.6 lb. abs., is used for the evaporators as described and for two closed heaters. Between the two closed heaters, No. 1 and No. 2, is interposed an auxiliary condenser taking the exhaust of the turbine-driven auxiliaries and the vapor from the evaporator. Turbine-driven auxiliaries consist of the hotwell pumps, service water pumps, boiler feed pumps and spare exciter.

Condensate from the condenser hotwell pumped by the hotwell pumps, flows first through the governor and turbine oil coolers, generator air coolers and air ejector condenser to the suction of the boiler feed pump. Between the oil coolers and generators air coolers is provided a depression heat exchanger, supplied with condenser circulating water, to cool the condensate sufficiently to enable the correct generator air temperature to be maintained during hot weather.

Recirculation of the condensate to the condenser will be controlled by a thermostatic valve actuated by

the air temperature to the generator. Recirculation is automatic and intended for low loads, while the depression heater exchanger control is manual and intended for use only in hot weather.

Between the ejector coolers and boiler feed pump suction are condensate surge tanks, steam sealed by ½ lb. pressure steam from the exhaust header and protected against excessive pressure by a water sealed overflow. The location of these tanks in the basement is indicated in the plan, Fig. 6. A cork center steel float is provided for each surge tank to reduce the contact area of the water and steam.

Boiler feed pumps discharge through the 2700-sq. ft. No. 1 heater, the 2700-sq. ft. auxiliary condenser and the 1880-sq. ft. No. 2 heater, to the economizer. Gland sealing water is taken from the first stage of the boiler feed pump.

Number 2 heater and the auxiliary condenser are drained back to the No. 1 heater and from there pumped by a heater drain pump to the suction of the boiler feed pump. All three heaters were supplied by the Croll-Reynolds Engineering Co. All heaters are vented to the air cooler section of the main condenser. The absence of open heaters or deaerating equipment other than the condenser is unusual and precautions taken to exclude possibility of oxygen absorption in any part of the system well are illustrated by the use of the heating system evaporator. Details of the heat balance and surge tank arrangement will be covered in a later article.

Oiling system for the turbine consists of the Funk-De Laval system of purification as well as a Bowser system with one 3000-gal. tank for new oil, a 3000-gal. tank for dirty oil and 3000-gal. tank for cleaned oil. In addition there are six 150-gal. tanks of the barrel racking type for kerosene and other oils.

Coal Handling and Storage

Coal handling equipment is well illustrated by Figs. 11 and 13. Coal received by barge in the back channel is unloaded by grab bucket and a Mead-Morrison 400-t. per hr. tower to a 200-t. bunker from which it is fed by an apron feeder to a 36-in. belt, weighed on the belt by a Merrick weightometer on the way to the crusher; crushed and delivered to another 36-in. belt which discharges it over a screen to a 150-t. bunker. Fines are screened out and sent directly to the power house bunkers.

If the coal is to be used immediately, it is fed from the 150-t. bunker to a third 36-in. belt and taken to the power house, being distributed to the individual boiler bunkers by distributing belts shown in the plan of the station, Fig. 6.

If intended for storage, the crushed and screened

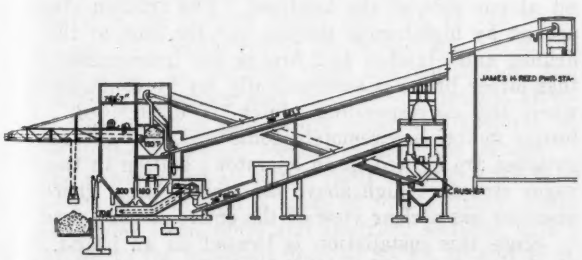


FIG. 11. COAL RECEIVED BY BARGE IS ELEVATED, WEIGHED AND CRUSHED, IN THESE TOWERS

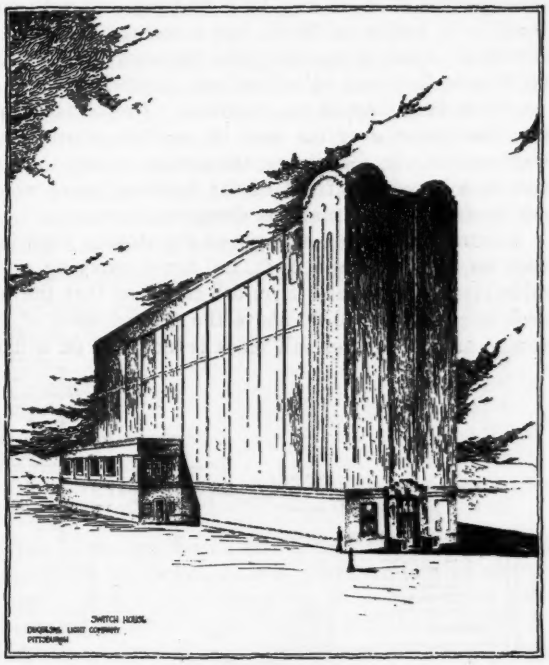


FIG. 12. ARCHITECTURAL TREATMENT OF THE SWITCH HOUSE SHOULD SERVE AS AN IDEAL TO THE INDUSTRY

coal is delivered from the 150-t. bunker to 40-t. side dump cars hauled by Milwaukee Locomotive Works gasoline locomotives to the storage area. Coal from storage is dumped direct to a 150-t. hopper served by the same 40-in. apron conveyor as the 200-t. bunker for barge unloading.

At the coal storage, the cars are dumped into a 100-t. hopper shown at the left of Fig. 13, fed onto a belt conveyor by a short apron conveyor and, by means of a second belt, delivered to the initial storage pile from which it is distributed by a Sauerman drag scraper. When reclaiming, coal is delivered to the 100-t. track hopper and goes through the same procedure except that when it reaches the top of the tower it is dropped directly to a 150-t. overhead bunker and delivered directly to the side dump cars instead of being deflected to the initial pile.

Drag Scraper

The coal storage yard, also shown in Fig. 13, is a

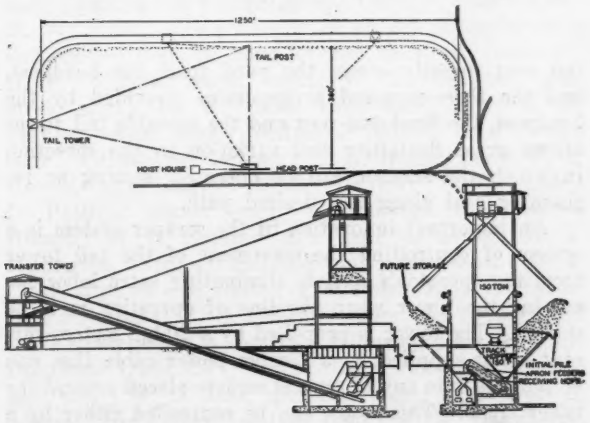


FIG. 13. COAL IN AND OUT OF STORAGE IS HANDLED BY THIS DRAG SCRAPER ARRANGEMENT

rectangle 360 ft. wide and 1250 ft. long, and with coal stored to a height of 30 ft. has a storage capacity of 250,000 t. Coal is spouted into the area, forming an initial pile in front of a headpost located midway of one of the long sides of the rectangle. From that point, it is distributed over the area by an 8-cu. yard power drag scraper. In reclaiming, the scraper brings the coal back to a hopper in front of the headpost from where it is returned to the plant as described previously.

Around the outer boundary of the storage yard is a track on which moves a 25-ft. tail tower carrying a tail guide block. The track is on a 5-ft. fill so that the tail block is supported 30 ft. above the ground level of the storage area. Another tail block is mounted on a fixed tail post directly across the yard from the headpost, and the three-cornered arrangement provided by the headpost, the fixed tail post and the movable tail tower allows great flexibility and variation in the direction in which the scraper can be operated, storing or reclaiming coal along any desired path.

An important innovation in the scraper system is a system of controlling the movement of the tail tower from the operator's station, eliminating extra labor for moving the tower when the line of operation is to be shifted. The tower is propelled by a 20-hp. motor, current being supplied by a flexible power cable that can be plugged into any of several sockets placed around the tower track. This motor can be controlled either by a switch on the tower or by a control switch at the operator's station in the scraper hoist house. The operator propels the tower whenever desired, without leaving his position and without the help of other workmen. The motor is likewise provided with a solenoid brake which locks the tower in place when not being propelled and as the stability of the tower is assured by the solenoid brake and the locking effect of the worm gear drive, the tower is designed without outriggers or rail clamps.

It is planned to store coal in comparatively shallow layers to allow all possible air to escape while the pile is being built up. This requires frequent shifting of the tail tower so that the convenience of controlling and propelling the tower without additional labor adds considerably to the efficiency of the installation. The comparatively high tail tower, supporting the tail block 25 ft. above the rail, was adopted so as to facilitate the rapid shifting of cables across the top of the coal pile.

The scraper power unit is a 200-hp. electric hoist, set at one side of the headpost. The friction clutches are set by high-torque motors, one for each of the two drums, and clutches and brakes are interconnected so that either brake is automatically set by counterweight when the corresponding clutch is disengaged. The torque motors are remotely controlled, and the control switches are located in an operator's station in the conveyor structure high above the storage area where the operator has a clear view of the entire storage yard.

Since this installation is located on an island, subject to periods of low visibility on account of fog so

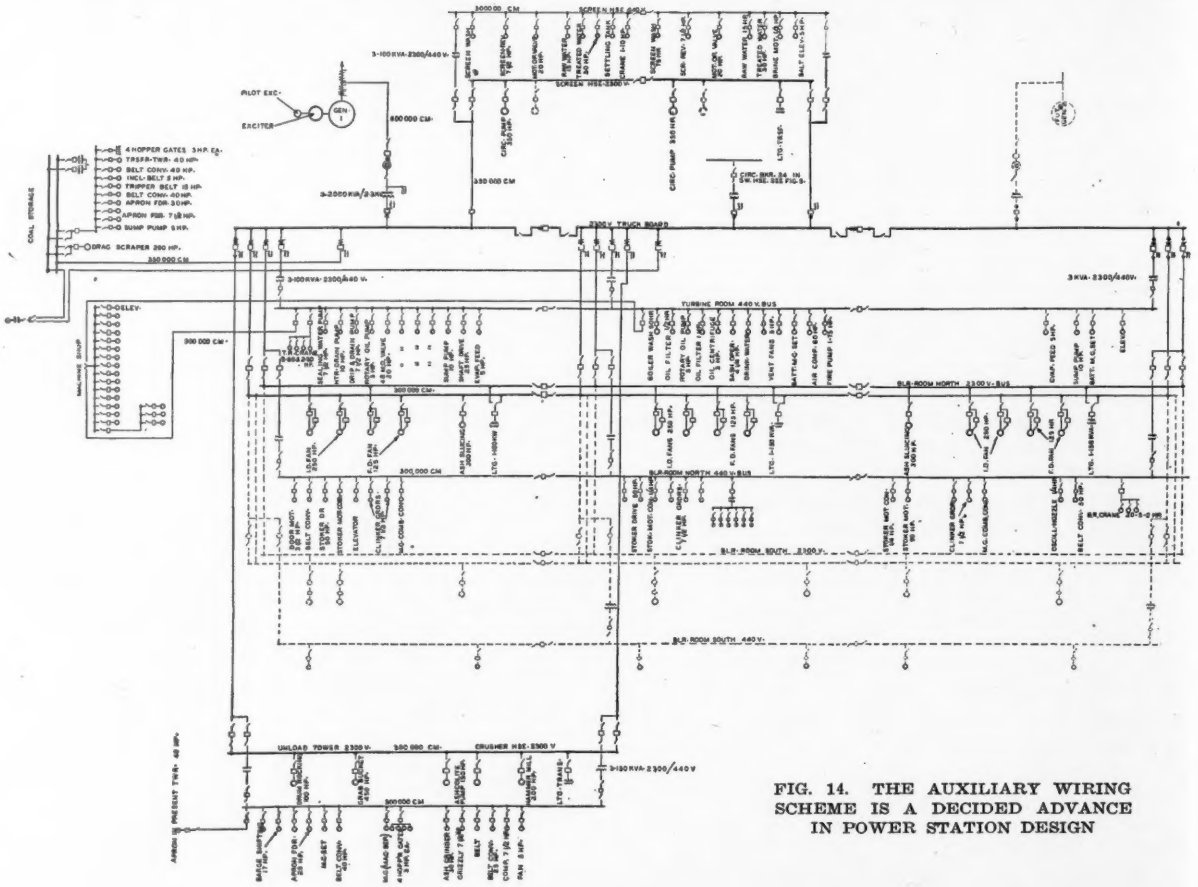


FIG. 14. THE AUXILIARY WIRING SCHEME IS A DECIDED ADVANCE IN POWER STATION DESIGN

that the operator cannot always watch the travel of the scraper, the system includes a special safety stop and signal system to indicate and limit the travel of the scraper bucket. The signal portion of this device, which consists of 24 lamps located in front of the hoist operator, is controlled by a geared selector switch of the drum type, with 24 contactors, and is located in the hoist house. It is driven from the hub of the front drum. These lamps are lighted successively as the load cable is wound up on the front drum (as the loaded scraper bucket is pulled across the storage yard) and extinguished successively as the cable is unreeled from the front drum (while the rear drum is returning the scraper to the loading point). The safety feature of the device consists of the necessary relays associated with the lamp circuit of the signal system so as to limit the travel of the scraper bucket in case of the operator's failure to disengage the clutch.

Station Auxiliary Power Supply

Auxiliary power is supplied from two sources as shown in Fig. 14. One supply taken directly from the generator leads through a bank of 6000-kv-a., 11,600/2300-v. transformer and oil circuit breakers, the other from the 12-kv. bus in the switch house, through a similar transformer bank and oil circuit breaker. Motors above 75 hp. are for 2300 v., the smaller ones are for 440-v. operation.

Pumps and auxiliary for each unit will be divided so that half the auxiliaries are normally carried on one supply and half on the other. A major failure of either supply will at most merely reduce the capacity of the main unit.

Although a radical departure from conventional design, the scheme is the first step taken toward a rational solution of the auxiliary power supply problem. It calls a halt on the growing complications and expense of so-called protection of the auxiliaries and provides protection which takes advantage of modern mechanical features of plant and auxiliary practice. This is one of the plant features which will be covered in detail in a subsequent article.

Reference to the switch house and features of design incorporated in it will be found on page 1362 of the December 15, 1929 issue of Power Plant Engineering. The construction and design are of unusual interest. Above the second floor, no reinforcing steel extends from one floor to another. Insulating joints between floors and similar joints running lengthwise of the structure at the center line efficiently check all flow of ground current between sections.

Building Design

Four cranes are provided: one 150-t. with a 10-t. auxiliary in the turbine room; one 10-t. in the boiler room; one 10-t. in the screen house and one 5-t. in the machine shop. In addition, there are one 2500-lb. and one 2000-lb. passenger and one 6000-lb. freight elevators. The machine shop, store room and hospital included in the design are located in the office section.

The power plant structure itself measures 249 ft. 5 in. by 217 ft. 9 in. and is made of four sections; boiler room, turbine room, office and electrical sections, with a height, above the basement floor, of 85, 86, 60 and 47 ft. respectively. The boiler room measures 170 ft. by 119 ft. 6 in. and the turbine room 208 ft. 7 in. by 75 ft. 1½ in.

Both soil and pile bearing foundations are used, safe loads on the Raymond concrete piles being used at 60,000 lb. each and soil bearing pressure at 7500 lb. per sq. ft. In order to take care of the upward force on the turbine room basement floor (some 28 ft. below high water) a concrete slab 15 ft. thick was used, circulating water tunnels being cast in the concrete. Details of the building design will be given later.

Some of the statistics regarding the power house are:

Building volume	4,746,534 cu. ft.
Excavation	85,000 cu. yd.
Piling	42,700 lin. ft.
Concrete	28,500 cu. yd.
Steel	5142 t.
Brick (all kinds)	2,255,000
Windows (536)	20,030 sq. ft.
Doors (171)	4752 sq. ft.
Copper	65,000 lb.

One of the interesting and little thought-of features, brought out by H. W. Fuller, vice-president in charge of engineering and construction, is in connection with the amount of drafting work necessary for a project of this kind. A total of 841 drawings were made. This is equivalent in time to 12,278 man-days and would have taken one man 47 yr. to complete.

One of the major difficulties fully realized at the time the station was first considered was the fact that the only railroad available was the Pennsylvania which crossed the island 48.5 ft. above the established elevation.

Elevator Lowers Cars 48.5 Ft.

To overcome this difficulty, a 200-t. car elevator, built by Wellman Eng. Co. and shown in Fig. 3 was used. This elevator is capable of lowering or raising the heaviest single part of a 75,000-kv-a. tubogenerator when loaded on the car in which shipped. It is operated by alternating current motors with push button control and will raise or lower in 5 min. The bumper which projects outward in the upper right-hand corner of the picture is capable of taking the shock of a loaded car traveling 10 mi. an hour.

Design and construction of the station was carried out by the Byllesby Engineering & Management Corp. in collaboration with the Duquesne Light Co. The following officials were in direct charge of the work: Byllesby Engineering & Management Corp. (Chicago office) H. W. Fuller, vice-president in charge of engineering and construction; H. Boyd Brydon, mech. en. (retired); H. S. Whiton, mech. engr.; W. A. Gardner, asst. mech. engr.; H. W. Eales, chief elec. engr.; R. M. Stanley, elect. engr.; Walter J. Welch, chief design engr. (Pittsburgh Branch) A. G. Butler, mgr.; F. S. Brown, elec. engr.; D. L. McNulty, mech. engr.; L. Phillips, design engr. (Pittsburgh Construction Branch) M. R. Sumner, gen. supt. of const.; W. J. Millington, supt. of building and mech. const.; E. J. Clark, supt. of elec. const.; G. E. Balch, supt. in charge. In Pittsburgh: F. R. Phillips, senior vice-president of the Philadelphia Co., and the following officials of the Duquesne Light Co.: E. W. Judy, vice-president and gen. mgr.; W. G. Jens, operating mgr.; T. E. Purcell, general supt. power station dept.; J. J. Dougherty, operating engr.

Control of Spontaneous Heating of Coal

Curative Measures Which Appear to Be Effective with Fremont County Slack in Colorado. By A. B. Colgate* and O. J. Rundahl*

SPONTANEOUS HEATING is the result of slow oxidation of several coal constituents. Normal oxidation begins as soon as the coal is mined and continues at a diminishing rate, for an indefinitely long period. It is primarily a surface phenomenon, the amount of heat liberated per unit of time being dependent on the exposed surface and the oxygen available. An increase of temperature also increases the rate of oxidation. The presence of alkali, particularly sodium hydroxide, causes a marked increase in the rate of oxidation.

The preceding paragraph states the five salient facts which govern the thermal behavior of any coal in storage, under any and all conditions. Destructive heating, liberating volatile carbon and rapidly resulting in combustion, takes place when the heat of oxidation accumulates more rapidly than it can be removed. Complete exclusion of air, or ventilation sufficient to dissipate heat as soon as liberated, will prevent destructive heating. Neither of these policies can be adhered to under all local conditions. These two states exist, however, in every large pile, and this fact has a direct bearing on conclusions to be drawn later.

Conflicting Theories Have Delayed Corrective Action

This memorandum will be set forth briefly in the following paragraphs the theoretical causes of destructive heating, with preventive and curative measures, applicable to storage conditions as they are. Obviously the more technical and involved causes of action are immaterial. This work is prompted by the fact that spontaneous heating has been responsible for the loss of a very great amount of coal over a period of many years. The prevalence of many conflicting and erroneous ideas on this subject, has resulted in a lack of any well defined and practicable policy for controlling destructive heat, and has often made it difficult to obtain dependable results from experimental measures.

All data necessary for a successful solution of a spontaneous heating problem, appears to be included in Technical Paper No. 409, U. S. Bureau of Mines, "Spontaneous Heating of Coal." After presenting a great mass of scientific findings, however, the authors of the paper are rather vague as to conclusions. The results of numerous tests plainly show that conditions of storage must prescribe the preventive or curative measures which will be effective.

Danger Zone Exists in All Large Coal Piles

Certain physical factors have been found to be important in affecting thermal conditions. The conclusions of scientists are verified by years of experience. Observed phenomena, however, have been often ascribed an erroneous relationship to the actual process. Before enumerating these factors it may be noted that the logic of this article is based on the theory of a danger zone in every large mass of mined coal. Outside of this zone, the air circulates freely enough to remove the heat as soon as it is liberated. Inside the zone, there is an insufficiency of air and the rate of oxidation is slow, building up no dangerous temperatures. This theory is supported by all observations made during the last two years. Its acceptance explains many mysterious exhibitions, and paves the way for the abandonment of several long standing beliefs.

Finer portions of slack are more susceptible to heating, particularly if segregated. This is due primarily to the larger surface area per cubic foot. The heat is disseminated through streaks of coarser coal, setting up a chimney action tending to draw fresh air to the seat of trouble and accelerate the action. The heat frequently becomes evident in the coarse coal, because of more rapid dissemination. This has given rise to the belief that coarse coal is dangerous. As the heat rises through the more open spaces of the pile, it naturally becomes evident on the high points, leading to the belief that the high pile is dangerous. When the temperature at the source of dangerous heat vaporizes water, large quantities of latent heat are carried out into cooler parts of the pile and released, thus spreading the high temperature area. The presence of moisture with the heat has led to the belief that moisture is dangerous.

Drenching with Water Obvious Remedy

These physical factors: size of coal; depth of pile; presence of moisture, as well as the season of the year, are not to be ignored, as they undoubtedly play a part in destructive heating. In other words, if a medium coarse coal, of uniform size throughout, were stored in a dry state, at a time of year when fluctuations of atmospheric temperature are at a minimum, in a pile not over six feet deep, there would be no heating problem. But, as has been previously stated, it is necessary to meet conditions as they are. It appears highly probable that rational supervision can positively control the situation, regardless of the depth of pile or size and condition of coal. Obviously the task is not so great if adverse physical factors are recognized and avoided as far as practicable when coal is put in storage.

The curative measure proposed in Colorado with Fremont County slack is probably the oldest and most obvious one, namely, drenching with water. Its failure to give satisfactory results is believed to have been due to one or more of the following faults: not drenched at the right time (nothing is gained by premature application, and if heating has progressed too far it is difficult to cover the affected area); not applied at the right place (unless the actual source of heating is drenched, water acts as a rapid disseminator of heat as well as a possible catalyst); lack of thoroughness (if a section is slighted, the evils of the preceding fault are soon evi-

*With the Southern Colorado Power Co., Canon City, Colo.

dent). Parenthetically, a contradictory observation was recently made. An area of fine coal heated spontaneously and was drenched over the hot zone, on the slope of the pile, the main heap being about 12 ft. deep. A spot about 5 ft. in diameter, on top of the pile, emitting vapor and some gas, at abnormal temperature, was purposely left untreated; three days later, the heat had entirely subsided.

Water Has Threefold Action

Some coals are more susceptible to heating than others. Also storage conditions are seldom the same. Some piles will heat very quickly, some never build up high temperatures. Water should be applied as soon as unusual heating is noted. This may be determined by a variety of methods; heat becomes evident at the higher parts of the pile, or along streaks of coarser coal before the action has made much destructive progress.

Water should be applied in such a way that it covers all of the affected area and percolates through the sources of heat in quantities sufficient to cool them off. Water so applied cools off the affected mass, breaks up

COAL AND ASH ANALYSIS
SYLLABUS E. & M. CORP. FORM C-48A

NO. _____ CAR NO. _____

COMPANY So. Colo. Power Co. DIV. Canon City

KIND OF FUEL Composite Slack

FROM _____ DATE SAMPLED Jan.-1930 DATE ANALYZED _____

FUEL ANALYSIS		PHYSICAL PROPERTIES	ASH ANALYSIS
% MOISTURE	5.80	COKING No	% COMBUSTIBLE
% VOLATILE	32.21	COST PER TON	% NON-COMBUST.
% FIXED CARBON	49.87	FREIGHT	TOTAL
% COMBUSTIBLE		TOTAL COST PER TON	
% ASH	12.12	COST MILLION B.T.U.	REMARKS
CORRECTED RISE			
B.T.U. PER LB. DRY	11730		
B.T.U. PER LB. AS FIRED	11050		
B.T.U. PER LB. COMBUST.	13459		

REMARKS: Includes coal from five different mines in this area.

REPORT TO _____ A.B. Coalgate TESTING BUREAU

TYPICAL PROXIMATE ANALYSIS OF THE COAL SPECIFICALLY REFERRED TO IN THE ARTICLE

the chimney action by packing the fines in the interstices and dissolves alkali carrying it to lower and safer levels.

Technical Paper No. 409, in discussing the factors affecting spontaneous heating (pages 50 to 63), presents several interesting curves, clearly indicating a certain danger zone from which the trouble originates. It is not difficult to visualize an ideal situation for whatever depth the kind and size of coal and physical state may fix. Outside the danger zone, oxidation is less than dissemination due to excess air. Inside the zone there is an insufficiency of air, and oxidation is slow. The temperature of the coal at the zone reaches the so-called critical point: the rate of oxidation on both sides is increased, and circulation of air becomes comparatively rapid through adjacent coarse sections of the pile.

At this stage an excess of water is applied. First, the entire mass is cooled, and the entire rate of oxidation is lowered. At the same time the coal is packed, the fines settle among the coarser masses, thus changing the physical factors of the pile. The final result is that any future zone of highest temperature will be nearer the surface, at which location the coal has probably passed the danger stage, as the normal rate of oxidation decreases from the time it is mined.

This mehod has not failed to prove affective here. It has been applied to three piles from 10 to 15 ft. in depth and containing more than 10,000 t. of slack. One pile of the most susceptible coals, mixed, about 12 ft. deep and containing approximately 1000 t., was drenched. Six weeks later it shows no sign of again heating, though the exposure of one side would seem to invite a secondary zone composed of coal buried too deeply to be affected by the first action. Apparently it is feasible to stock coal to any desired depth, as the very deep portions show no tendency to heat and deterioration is extremely slow.

The following citations from Paper No. 409 have a direct bearing on our local problem:

Page 2—"When the balance between generation and dissipation is reached at moderate temperatures, there is no further storage of heat, and temperature ceases to rise."

Pages 4 and 5. (Fayol)—"Slack that passes a 20-mm. screen heats and fires spontaneously, whenever it is in large enough heaps." "Coal in fine powder is a little less inflammable than screened slack." "Heating has never occurred in piles less than two meters high, but often occurs in piles higher than four meters." "Atmospheric influences, such as heat, cold, drought and damp, have little or no influence on progress of oxidation."

Page 5. (Lewes)—"Coal which has once heated, even slightly, and then cooled down, is insensitive to oxidation."

Page 6. (Threlfall)—"Large scale comparison of wet and dry coal indicates that the dry state was more dangerous." This contradicts the laboratory tests of Dennstedt and Buenz.

Page 7. (Erdmann)—Moisture decreased inflammability. Laboratory tests.

Page 9. (Porter, Billington and Cameron)—Explain that apparent adverse reports in regard to wet coal cannot be taken in an ordinary commercial sense. Excess of moisture actually retards oxidation, while the dry state sometimes noted as favorable is not commercially possible of attainment. U. S. Bureau of Mines fully supports this statement.

Page 22—Discussion presumes a zone of heating, which must be the source of progressive oxidation, regardless of the factors of dissemination.

Page 33—"Slow oxidation of high rank coals destroys their coking powers."

Page 37—"Spontaneous combustion occurs, if at all, in from eight to twelve weeks."—(Local experience of the authors notes occurrences over both greater and lesser periods.)

Page 45—Discusses the effect of moisture. Moisture may act as a catalyst, but whether or not, the fact has no bearing on the effect of drenching, as only the natural moisture content is considered and this is in all cases sufficient for catalysis.

Page 47. (Schrader)—"Alkali, particularly sodium hydroxide, causes a marked increase in rates of oxidation." (The authors verify this and determine that the rate is doubled.)

Wrought iron has a "grain" like wood which may be seen without a microscope, if the substance is etched with strong acid to lay the fibers bare.

Mill Drying Coal with 550 Deg. F. Flue Gas

LAKESIDE 1929 EXTENSION WITH FIRST INSTALLATION OF THIS KIND FOR CENTRAL SYSTEM, SHOWS ONE PER CENT INCREASE IN EFFICIENCY OVER OLDER METHOD

MANY DESIRABLE FEATURES are incorporated in a new system of mill drying applied to two 15-ton pulverizing mills in the 1390-lb., 1929 Lakeside Station Extension of the Milwaukee Electric Railway & Light Co.

Always a pioneer, Lakeside has applied two relatively new principles of coal pulverizing and drying to this installation, which is represented diagrammatically in Fig. 1. First, the mill exhauster is placed on the suction side of the collector so that it handles practically

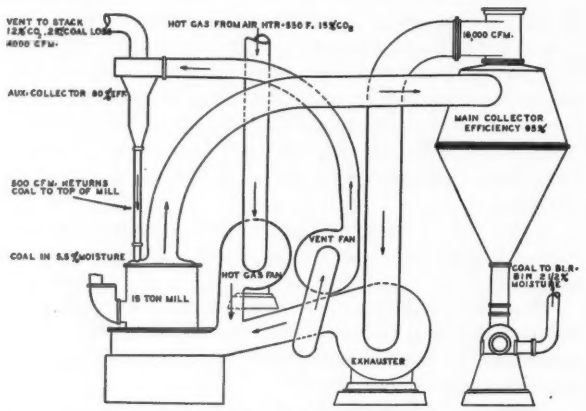


FIG. 1. DIAGRAMMATIC REPRESENTATION OF THE SYSTEM AS USED ON TWO 15-TON MILLS

no coal. This has been used on the two previous installations. Second, drying is accomplished by 550 deg. F. flue gas taken from the boiler system just before the gas enters the air heater. This is thought to be the first time the system has been used in a central station.

CYCLONE EFFICIENCY 80 PER CENT

Gas vented from the system is sent through auxiliary cyclones to the stack, the auxiliary cyclones discharging the separated coal into the tops of the mills. It has been found that the efficiency of these cyclones are improved by allowing a considerable downward flow of air as shown in the drawing, Fig. 1. With the gas flows indicated and vented coal of 98 per cent through 325 mesh, the efficiency of the collectors averages 80 per cent. Two cyclones are employed to give high separating efficiency over a wide range of operation and coal loss to the stack under the conditions of operation shown averages around 0.25 per cent.

A heat balance of the system shows a credit of 0.75 per cent to the mill drying system for reducing the flue gas losses of the boiler unit and a debit of 0.25 per cent for coal lost in the vent, indicating a net savings due to the drying process of 0.5 per cent. Drying is accomplished more cheaply than it can be done by air drying or in the furnaces because the system actually improves the boiler room efficiency 0.5 per cent. This system is one per cent more efficient than the older drying method.

Since the required flue gas is taken at the inlet to the air heater, flue gas heat losses from the air heater exit are reduced because less heat needs to be transferred and the ratio of air to gas is considerably increased. This gain is increased as the boiler outlet gas temperature is raised as in the case where economizers are not used. This advantage would be lost if the drying system were vented to the furnace. Again, about 6 per cent of the flue gases used for drying are reduced to a temperature of around 150 deg. F. instead of 350 deg. as exists at the outlet of the air heater.

By using higher flue gas temperatures, the moisture removal capacity of the system can be increased. When using 550 deg. F. gas and venting 25 per cent, 3 per cent moisture can be removed; using 750 deg. F. gas and venting 55 per cent, 7 per cent moisture can be removed and by using higher temperature or more venting, 10 per cent moisture can be removed.

FIRE HAZARD ELIMINATED

Such high temperatures can be used because practically inert gas is used in the system so that the fire hazard does not exist. Approximately 12 per cent CO_2 is maintained in the mill system and this effectively prevents smoldering of coal particles which may collect at points where it is subjected to the high temperature gases.

The three outstanding advantages of the system are, therefore, reduction of fire hazard, high moisture removal capacity and reduction of flue gas losses from the boiler. Against these advantages may be listed the possible disadvantage of storing the higher temperature coal in bunkers. Temperature in the mill system must be higher than with an air system because of the higher moisture content of the flue gases.

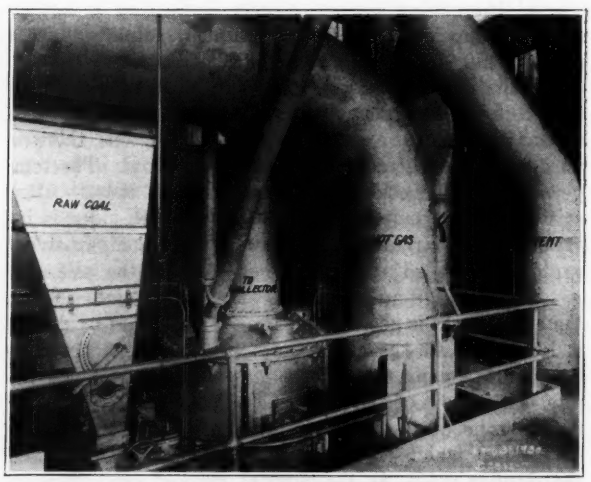


FIG. 2. ACTUAL INSTALLATION MARKED TO AGREE WITH FIG. 1

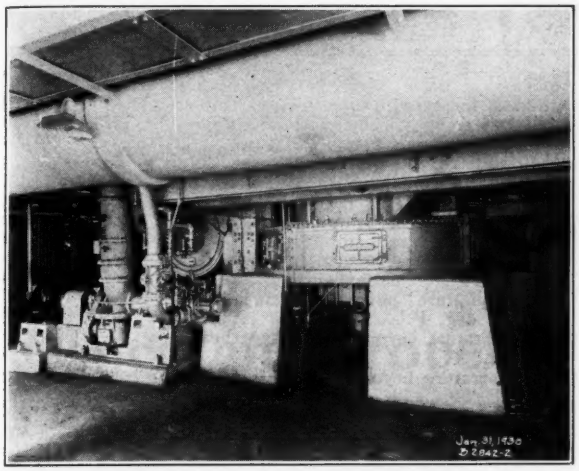


FIG. 3. VIEW TAKEN FROM THE LEVEL BELOW FIG. 2 SHOWING THE COMPACT AND CLEAN CUT INSTALLATION

This is of interest where the coal would have to be stored for considerable periods of time due to boiler outage. Of course separately fired dryers and usual venting practice have in the past given temperatures of 150 deg. F. so that this new system does not create any new difficulties, although it is not as desirable as air drying when viewed from this standpoint.

All piping and cyclones are insulated to eliminate corrosion, the only deterioration in the system apparently being due to erosion. Test pieces placed in locations considered most favorable to corrosion seem to indicate that corrosion is no more likely to occur here than it is in air drying systems so that it is thought that the only difficulty to be expected is with the wet coal supply to the mills through hoppers and feeders.

Water in Steam Is the Cause of Many Operating Troubles

WET STEAM is a frequent and sometimes serious complaint which is being given more attention than formerly. This is due to a number of causes, probably the most urgent ones being the demand for higher boiler ratings and the highest practical superheat.

Moisture in the steam, that is, moisture in excess of about one per cent, is commonly spoken of as priming or foaming. Foaming, technically speaking, differs from priming in that it is due to a combination of suspended solids and soluble salts or an oil or soapy condition which increases the surface tension to the point where bubbles form permanently and partially or completely fill the steam space. Wet steam from this source is most likely to be somewhere near constant, rather than in slugs of water and, of course, is more pronounced at high ratings.

Water May Be Lost Quickly When Boilers Prime

Priming, on the other hand, is more likely to be spasmodic and the water loss from the boiler may at times almost equal the steam flow. A number of factors enter into the problem, among them the concentration of soluble and unsoluble salts, the character of the load, high ratings, high water level and boiler design. For instance, in some boilers a combination of high water and sudden load will start priming so severe that a glass full of water will be lost so fast that it is almost impossible to follow its drop with the eye.

It seems hard to visualize steam with a quality of 50 or 60 per cent until the different densities of water and steam are remembered. Steam quality is based on weight and indicates the percentage of steam. If a pound of water is completely evaporated, the quality of the steam is 100 per cent. If it were cooled, so that 10 per cent of it condensed back to water, the quality would be 90 per cent and so on down until it was all condensed again, at which point the quality would be zero, that is, no steam.

At 100 lb. abs. pressure, the specific volume or cubic feet per pound of saturated steam is 4.429. If the quality were reduced to 50 per cent, the volume of the steam and water mixture would be one-half of this, or 2.215 plus the volume of one-half a pound of water, which is only about 0.008 cu. ft., bringing the total up to about 2.203; that is, at this pressure steam of 50 per cent quality has less than 0.4 per cent of water by volume.

Changing Boiler Design Baffling and Use of Purifiers Help Solve Problem

Thinking of it in this way, it is easy to understand that when slow speed engines with 5 per cent or more of clearance knock off a cylinder head, even a lower quality than 50 per cent is present. Of course, wrecks of this kind are caused by slugs of water which may come directly from the boiler, or the slug may collect at some place in the line by separation over a long period from steam that has comparatively little water.

Priming and foaming are, perhaps, not always the correct terms because moisture sometimes occurs when chemical and mechanical conditions are not favorable for priming or foaming as we know it. This usually happens at high ratings and is sometimes called entrainment, evidently caused by particles of water thrown out when the steam bubbles break through the surface and are carried out with the steam before they can separate. This entrainment is usually a function of the boiler rating and may run up to four or five per cent.

Changing the boiler design, baffling the drums, adding steam purifiers, and better feedwater treatment are some of the common remedies. Wet steam causes trouble from loss of superheat, because the superheater has to evaporate the excess moisture; abrasion of steam lines, valves, turbine blade and engine cylinders by the dry particles and often chemical corrosion due to the chemicals which are carried over and deposited on the warm parts.

IN THE SYSTEM of coal classification followed by the United States Geographical survey, each coal has a place or rank according to the ratio of fixed carbon to volatile matter. There is no definite line of demarcation as the ranks overlie and grade into each other. As used, the ratios are as follows: anthracite, 10 to 60; semi-anthracite, 6 to 10; semi-bituminous, 3 to 7; bituminous, 3; sub-bituminous, 1, and lignite, 1. This classification is not so suitable to the lower grades and physical characteristics must also be considered.

PROTECTION TUBES used with thermocouples may produce errors if not properly installed and used.

Results of Mercury Vapor Cycle at Hartford

FIGURES INDICATE 8900 B.T.U. PER NET KW-HR. IS POSSIBLE. BY W. L. R. EMMET*

RATED AT 10,000 kw., the mercury vapor process installation at South Meadow Station of the Hartford Electric Light Co., was completed and put in service in November, 1928. The initial installation in the

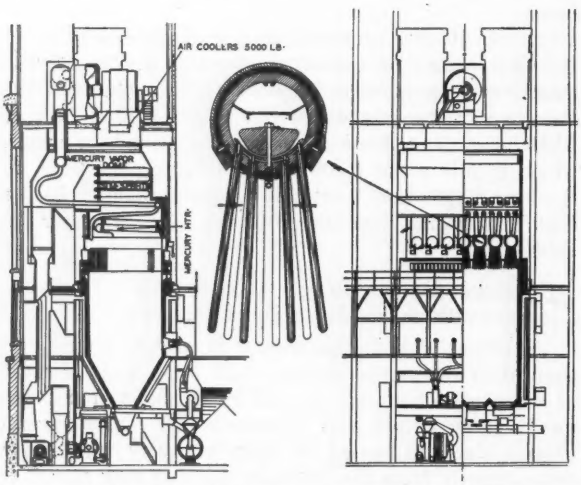


FIG. 1. CROSS-SECTION OF THE PLANT AND DETAILS OF THE BOILER DRUM

Dutch Point Station of the same company was rated at 2000 kw.

Results accomplished while this equipment was running, gave clear indications of the economies attainable. The character of the installation may be seen from Figs. 1 and 2, showing the arrangement and some details of the apparatus.

Results for which this equipment was designed in comparison with the results shown by the highest load trial run which was made by the unit while it was in operation are tabulated in the accompanying table.

*Consulting Engineer, General Electric Co. From a paper presented at the World Engineering Conference, Tokio, Japan.

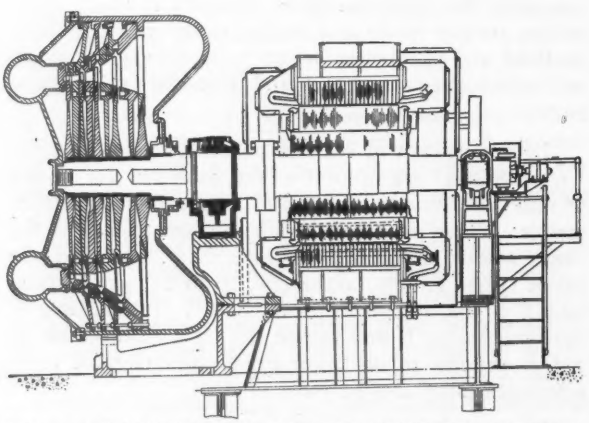


FIG. 2. CROSS-SECTION OF THE MERCURY TURBINE. NOTE THE PROVISION IN THE TURBINE CASING TO DRAIN CONDENSED MERCURY TO THE EXHAUST SPACE

DATA ON PERFORMANCE OF THE 10,000-KW. MERCURY INSTALLATION

	As designed	From test
Output of mercury turbine, kw	10,000	10,300
Speed of mercury turbine, r.p.m.	720	720
Steam produced per hr., lb	125,000	130,000
Steam pressure, lb. g	350	270
Steam temperature, deg. F	700	810
Mercury vaporized per hr., lb	1,150,000	
Temperature mercury vapor, deg. F	884	880
Pressure vapor at mercury turbine, lb. g	70	68
Vacuum in mercury condenser, in	28	28.5
Temperature mercury exhaust, deg. F	458	
Gas temperature beyond mercury liquid heater, deg. F	950	1100
Gas temperature beyond steam superheater, deg. F.	650	720
Gas temperature beyond water economizer, deg. F.	480	
Gas temperature to stack, deg. F	280	310
Air temperature entering furnace, deg. F	390	400
Coal burned per hr., lb	14,500	15,500
Heat in coal per lb	14,500	14,300

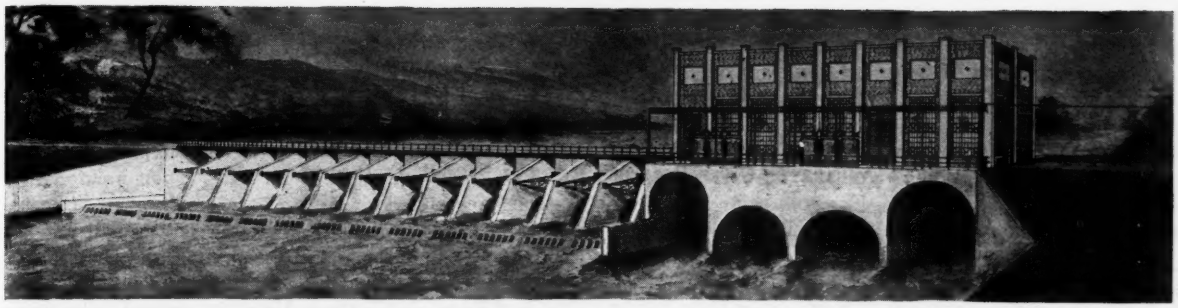
These figures show that the efficiency of the mercury turbine, combustion conditions and heat transfers in the surface beyond the mercury boiler were better than expected. The reduction of the gas temperature in the mercury boiler was materially less than was intended and this was corrected by the introduction of certain baffles to prevent bypassing and force the heated gases to pass through the heating surface of the mercury boiler in the most effective manner and with a distribution which should be equal instead of very unequal as was the case in the trial reported.

Correction of these defects would put more heat in the mercury and thus improve the net economy. Such steam as was made in this trial, if used in the best large apparatus and with the best methods of regenerative feed heating, would produce 14,000 kw. plus all necessary auxiliary power. This should give 24,300 kw. from a consumption of 15,500 lb. of 14,300 B.t.u. coal per hour, or 9140 B.t.u. per kw-hr.

In future applications of this process, mercury heating surface on the walls of furnaces will probably be used. This will deliver more of the total heat of the fuel to the mercury vapor, make it possible to dispense with the economizer and use more air heating and a much greater application of regenerative feed heating. The figures given above clearly indicate that under such improved conditions a properly designed plant with the best steam apparatus could produce power at the rate of 8900 B.t.u. from fuel per net kw-hr.

This unit, while operating, was actually saving its users about $800 per day in fuel alone. Except in the boiler there was no trouble and no observable deterioration. There was no erosion in the mercury turbine, the furnace showed no deterioration and the heating surface was easily kept clean.

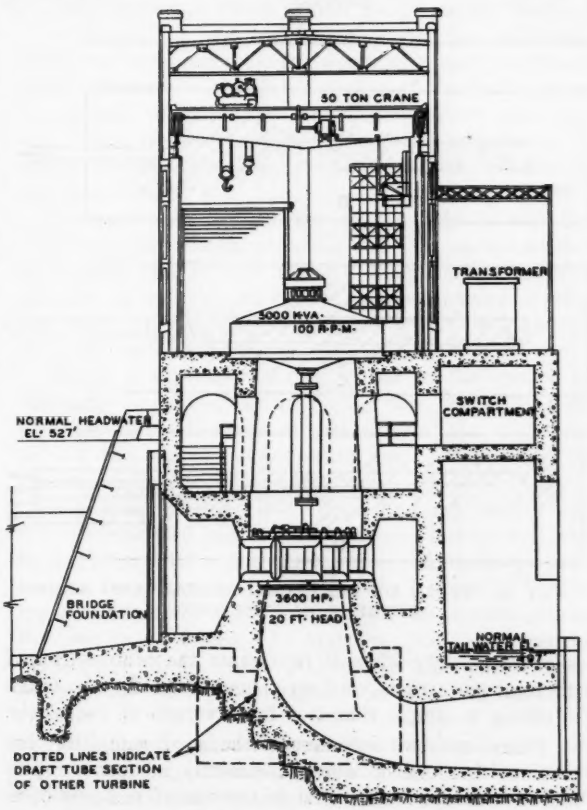
Plans for the further development of this process include carrying considerable degrees of overload by the simple increase of firing, accompanied by increase of pressure in the mercury vapor. By using a larger generator and a little different arrangement of heating surface a pressure of 100 lb. g. will give over 40 per cent increase of output from a mercury turbine and, owing to the higher temperature limit, the fuel efficiency will be better notwithstanding the greater congestion of the apparatus and of the heating surfaces.

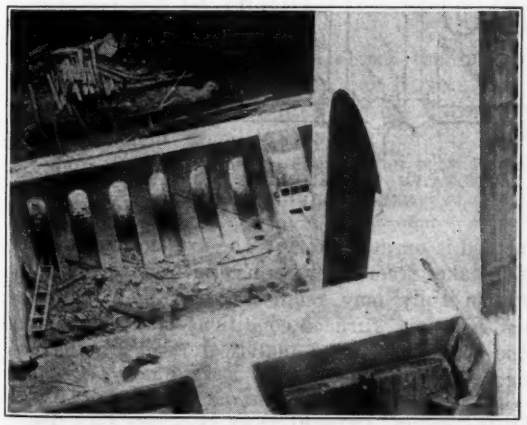


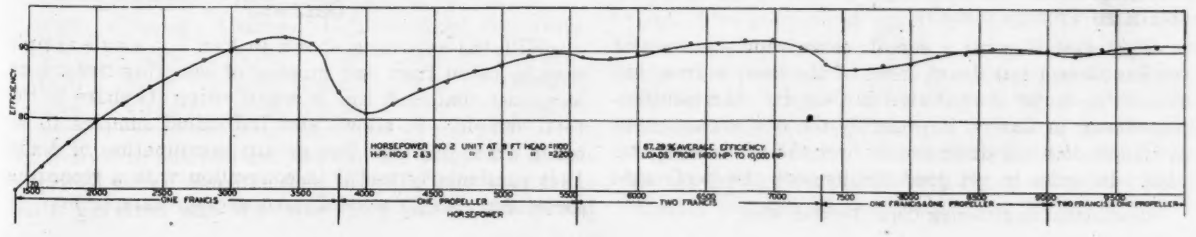
Francis and Propeller Runners Combined at Flint River Plant

HIGH EFFICIENCY at normal head and high power at low head were sought in the design of a new hydroelectric plant recently built on the Flint River in Georgia for the Hydroelectric Power Commission of Crisp County. To attain this object, the plant was designed to have two Francis turbines and two propeller type turbines, one of each being installed now. The Francis turbines are Newport News units rated at 3600 hp. each at 30-ft. head; the propeller units are Newport News machines each rated at 3600 hp. at 20 ft. head. Below is shown the mass efficiency curve for various combinations of units. Each Francis turbine drives a 3000-kv-a., 0.8-p.f., 2300-v., 3-phase, 60-cycle G.E. generator at 100 r.p.m. Each propeller turbine drives a 5000-kv-a., 0.8 p.f., 2300-v. G.E. generator at 100 r.p.m.

Another feature of this plant, which was designed by Emmet S. Killebrew, Hydroelectric Engineer, Cordele, Ga., with J. E. Sirrine & Co. as consultant, is the cease pool on the spillway to prevent scouring of the foundation bed beyond the protected area. Discharge from the Tainter gates enters the cease pool and part of its energy is dissipated. The remaining water encounters the curved obstruction downstream, which directs half of it through the openings as jets. The other half is directed vertically upwards, its energy being dissipated by gravity. (When the pool level is low, this part of the water may spout upwards 20 ft.) All flow over topping the obstruction rides the jets instead of scouring stream bed and foundation.







Sampling Flue Gases for Analysis

ORIFICE NIPPLES USED IN MULTIPLE WITH GAS ORSAT APPARATUS GIVES RELIABLE RESULTS. BY P. D. PLACE*

DESIRABILITY of determining, intermittently or continuously, the composition of boiler flue gases as a method of controlling furnace operation, is unquestioned. Obviously, the analysis of the gas sample

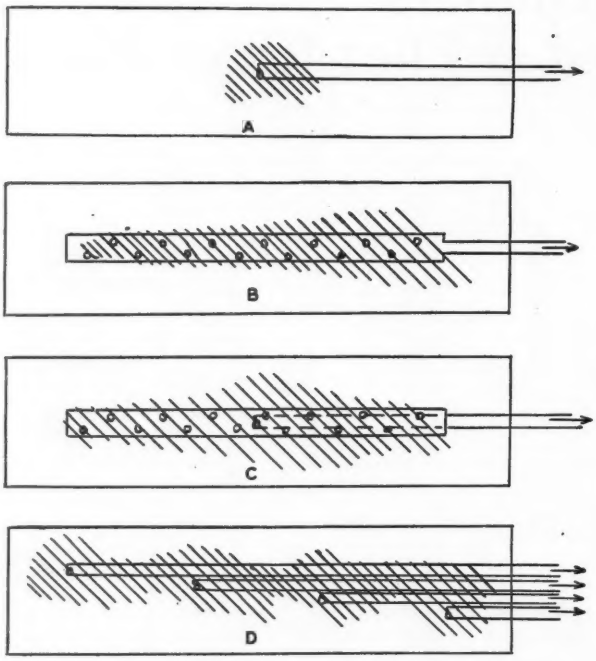


FIG. 1. TYPES OF SAMPLING NOZZLES AND AREAS COVERED IN BREECHING

is of value only when it represents the composition of the total gas stream, and care should therefore be taken to obtain a sample that is a fair average of the whole.

There are two common methods of sampling flue gases neither one of which necessarily insures a representative sample. The first is the use of a single open ended pipe located near the center of the gas stream. This method gives an admittedly local sample and is justified only by its simplicity and the assumption that the composition of the gas stream is the same throughout. The portion of the gas passage covered by such a nozzle is roughly indicated in Case A, Fig. 1. The second method is the use of various modifications of a perforated pipe designed to draw portions of the sample from various locations in the gas stream and thereby to obtain an average sample.

This method gives a sample more representative of the gas stream but draws most of the sample from one side of the boiler as indicated in Case B. The modification shown in Case C is probably the best arrangement of all but does not draw evenly over the whole sampling pipe. In order to get good results with the perforated sampling pipes, the perforations must be small and are continually plugging up with flue dust and soot.

For test purposes where an average sample is essential and traverse readings desirable, several open ended lines are installed and piped separately as shown in Case D. Gas samples may be drawn successively from each line and the results averaged. In most cases, four or five nozzles, symmetrically located across the gas passage, are sufficient to furnish an average sample of the gas stream.

FURNACE CONDITIONS MAY CHANGE QUICKLY

For routine work and for test work where the furnace conditions are unsteady and vary continually, even this method is unsatisfactory. The average Orsat determination takes from 3 to 5 min. and to cover the total gas stream fully may require a half hour or more. During this time, furnace conditions may change several times and cause the analytical results to be misleading.

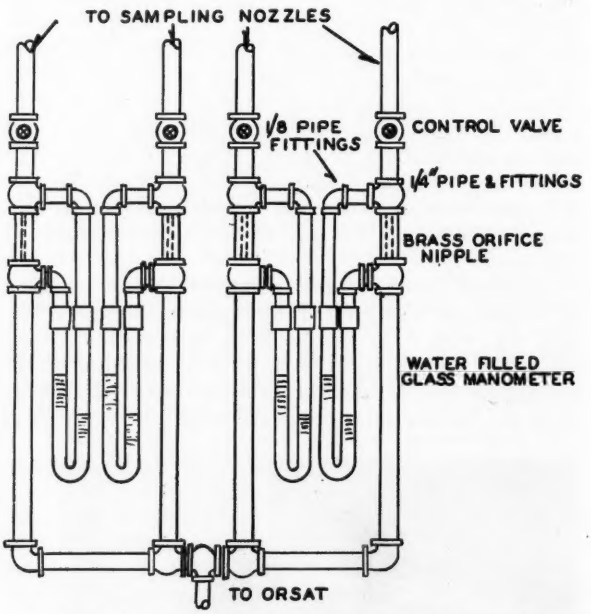


FIG. 2. DETAILS OF SAMPLING TUBE ARRANGEMENT USING ORIFICE NIPPLES

CONTINUOUS OR INTERMITTENT SAMPLES CAN BE OBTAINED

With the apparatus shown in Fig. 2, a single sample may be taken from any number of sampling lines, with assurance that each line is contributing its share to the total sample. It allows also individual samples to be taken from any one line or any combination of lines. It is particularly useful in connection with a recording meter for routine control. An average sample may be

*Combustion Engineering Corp., Detroit, Mich.

recorded continuously and traverse readings taken once during each shift for 15-min. periods, to record fuel distribution in the furnace, and indications of leakage.

An installation of four sampling lines is shown in Fig. 2. Each line has a standard sized brass orifice nipple in it and across this orifice is installed a small water manometer. By adjusting the valves and the pressure drop across each orifice, each line can be made to deliver the same amount of gas or any proportional amount of gas desired in the sample for analysis. By equalizing the pressure drops across all of the orifices, an average sample from all of the lines is obtained and by closing all but one valve, single samples from any one line may be taken.

All Orifices Should Be Similar

Construction is sturdy, simple and chiefly of standard ¼ and ⅛-in. pipe and fittings. The glass manometers are connected with short lengths of rubber tubing and are removable for cleaning and filling. The orifices are conveniently made from solid brass rod, drilled to $\frac{3}{32}$ in. diam. hole and threaded to fit ¼-in. pipe fittings as shown in Fig. 3. All of the orifices in any one outfit should be alike to give the same gas flow

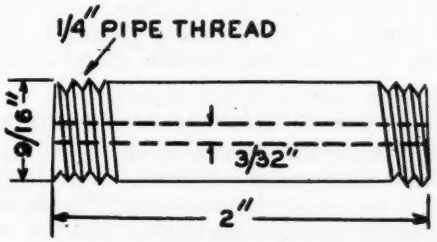


FIG. 3. ORIFICE FOR USE WITH EQUIPMENT IN FIG. 2

for equal pressure drops. The whole may be assembled and permanently mounted on a panel conveniently fastened to the Orsat stand. All connections and joints should be made with red lead, and preferably shellaced to prevent leakage. Valve packings must be tight and periodically tested for leakage.

Typical traverse analyses across the boiler outlet pass are given in Table I. It may be seen that single samples taken near the center of the gas stream may be quite different from the average of the whole gas stream. Table II shows a comparison between averages

Table I. Typical CO_2 Traverses of Boiler Passes

Right	Right Center	Left Center	Left	Average
13.4	14.0	13.8	12.9	13.52%
10.4	11.2	11.5	10.6	10.92%

Table II. Comparison Between Averages of Individual and Composite Average Samples

Right	Right Center	Left Center	Left	Average	Composite
9.33	9.85	9.94	9.49	9.75	9.65%
9.70	10.07	10.07	9.45	9.82	9.90%
9.90	10.24	10.22	9.46	9.95	9.95%

of individual samples and the average composite sample obtained with a four line sampler. The data were taken on a gas fired unit that was exceptionally steady and offered an excellent chance to check the reliability of the method. Over a period of four days, the average of all individual samples was 9.83 per cent CO_2 as compared to 9.84 per cent CO_2 for the average of all composite samples.

When used with pulverized fuel fired units, or wherever the gas is dirty and apt to plug the orifices, it is desirable to install in each line a filter or wash bottle, to clean the gas before it goes through the valves and orifices.

Using ¼-in. lines and fittings with ⅛-in. connections to the manometers, and $\frac{3}{32}$-in. diam. orifice nipples 2 in. long, a differential pressure of from 1 to 3 in. may be set up across the orifices when drawing gas samples.

Pump Tests Should Be Carefully Made

For testing a steam-driven reciprocating displacement pump, the test code recommends the following: tanks and platform scale for weighing water; graduated scales attached to the water glasses of the boiler; pressure gages, vacuum gages and thermometers with suitable wells; steam calorimeter; revolution counter or accurate speed measuring device; indicators; planimeter and dead-weight gage tester.

The gage on the discharge main should be attached near the pump discharge nozzle and that on the suction main near the suction nozzle. They should both be attached at an angle of 90 deg. to the direction of flow. The gage pipes should be provided with valves and air pet cock vents at the gages.

When a condenser is used either in the suction or discharge as part of the unit under test, the water head readings should be made at both sides of the condenser, so that the loss of head through the condenser will be charged against the main unit.

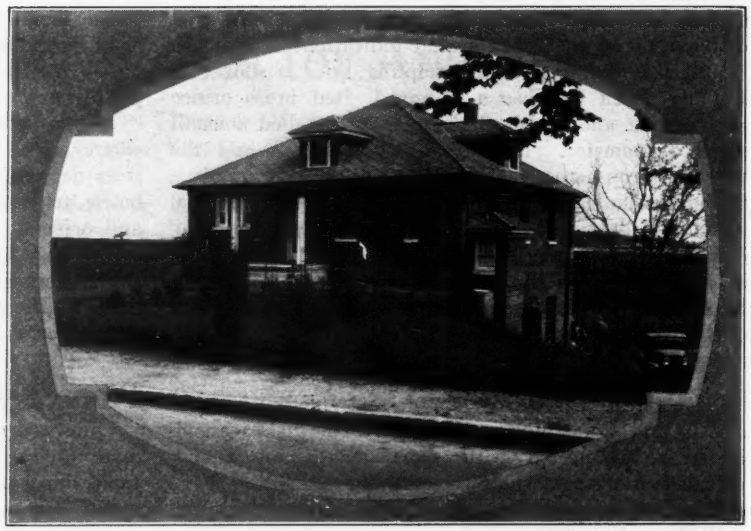
Tightness of the suction and discharge valves and for inside packed piston pumps the packing as well, can be determined by supplying the specified discharge pressure on the pumps and observing the leakage by removing a handhole or manhole cover on the suction side of the part being tested. If advisable, the valves can be made tight but the packing should leak a little bit so as to provide some lubrication and prevent excessive friction.

With inside packed piston direct-acting pumps, the leakage can be estimated by closing the discharge valve of the pump and running the pump just fast enough to maintain the desired discharge pressure. If it is excessive, the valves or packing can be tightened. This leakage or slip is determined this way by measuring the number of strokes per minute necessary to maintain the pressure. To deliver a specified quantity, the actual displacement of the pump must be increased by this amount.

Standard type ball bearings are made to international dimensions and are interchangeable with other American and foreign makes. The different types are known as; single row radial; single row radial thrust; double row; magneto or open and thrust. With the exception of the thrust type, all will carry combination thrust or radial loads. The first type is the most popular, the thrust capacity is about 50 per cent of the radial capacity and can be carried in either direction.

Oyster Bay Uses Diesel Water Pumps

PRECAUTIONS TAKEN IN SELECTION OF EQUIPMENT AND IN DESIGN OF PLANT TO AVOID FEATURES OBJECTIONABLE TO RESIDENTIAL LOCATION OF DIESEL PLANT IN OYSTER BAY, LONG ISLAND



DIESEL POWER plants lend themselves to locations and to conditions of installation which are unique in power plant practice. Although the headpiece of this article represents a comfortable city dwelling, the building was primarily to house a small but completely equipped city water pumping plant. With the decision to change from steam to Diesel power came the question of establishing the new plant in a more convenient location. It happened that the most desirable location was one in which an ordinary power plant with attendant conditions would be objectionable.

Lack of dust, of smoke and odor and of objectionable noise and vibration made it possible to use the upper floors of a Diesel power plant to house the superintendent and his family, thus combining the provision of pleasant living quarters and facility for adequate supervision in simple form.

LOCATION OF DIESEL PLANT NOT OBJECTIONABLE

Location of Diesel power plants in residential districts is possible as is indicated by the attractiveness of the plant described. The fuel passes from car to engine through pipe lines without exposure. Equipment is now available whereby all odor or discharge of destructive products from the stock may be avoided and objectional noise eliminated. No part of Diesel operation involves dust production. Water and oil storage tanks may be situated under ground and fountain spray ponds employed instead of the customary cooling towers, thus removing the identifying features of the usual power plant.

PUMPING UNITS INSTALLED IN DUPLICATE

Two pumping units have been installed in the Oyster Bay plant. Each consists of a 60-hp. Worthington, two-cylinder, two-cycle, solid-injection, crosshead type Diesel engine with pre-combustion chamber, which is connected to an 11 by 12 in. Worthington vertical, triplex, single acting pump, designed to deliver 500 gal. per min. against a working pressure of 135 lb. per sq. in. Although permanent alinement was obtained by building an integral foundation, a flexible coupling was used for the connection between the engine and pump. A 3¼ by 4-in. Worthington feather valve compressor provides the starting air.

Valve chambers and crossheads of the pumps are made accessible for inspection and adjustment by ar-

FIG. 1. DUPLICATE PUMPING UNITS IN THE OYSTER BAY PLANT ARE SET IN A STRAIGHT LINE FOR CONVENIENCE

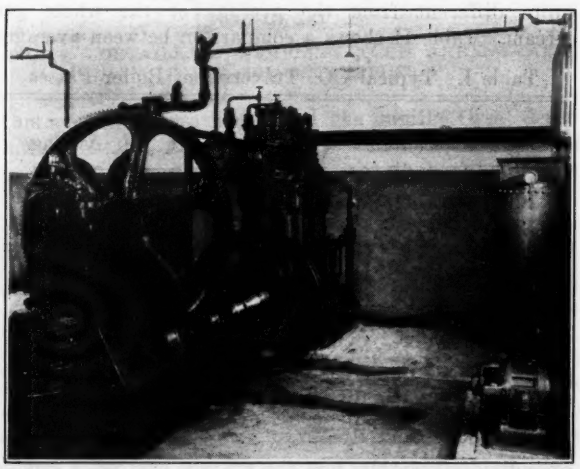


FIG. 2. DIRECT CONNECTION MAKES COMPACT PUMPING UNIT. COMPRESSOR UNIT FOR STARTING AIR SHOWN IN LOWER RIGHT CORNER

ranging the units in a straight line. Suction and discharge pipes are carried in a single checker plate covered trench through the middle of the building.

Reduction of Noise and Vibration a Feature

Unit operation being an important factor, the two-cycle type of engine was selected, since no valve gear is employed in this type and the fuel injection pumps are completely enclosed. Possibility of noisy piston slap was avoided by the crosshead construction which was adopted.

Smoothness of operation of the pumps was secured through the rigid frame construction. The frames are located between each crank and are mounted directly on the base. Crosshead guides are not used as tie pieces but are connected independently to the frames. Carefully cut herringbone gears, mounted on heavy shafts with bearings on each side, reduce the gear noise to a minimum.

Low Operating Costs

Average fuel and lubricant costs were found, after the first thousand hours of operation, to total less than one cent per 1000 gal. of water pumped. Engineers of the old steam plant, which was abandoned when the Diesel plant went into service, after receiving instruction in operation procedure, took over the operation of the plant.

Power Plant Materials-Handling Tools—I

Equipment for Condensing Water, Coal and Ashes. By W. W. Sayers*

TOOLS ARE INSTRUMENTS with which to do work. Usually some one tool is best suited for performing a particular function or purpose. While a task may be done with unsuitable tools, it can best be performed by using those suited to the work to be accomplished.

Tools may be efficient, mediocre or poor; suitable or unsuitable; dependable or unreliable. The selection and condition of the tools or equipment, since equipment is merely a set of tools, invariably indicates the skill of the workman or the efficiency of the plant.

Tools of the power plant are employed in preparing and handling materials such as condenser water, coal and ashes at the modern boiler house and to generate and deliver power. Manifestly, the modern plant should be provided with good, suitable tools for efficient, dependable operation.

Water Cleaning Tools

No tool chest of a condensing power plant is complete without a traveling water screen to insure refuse-free condenser water supply, to avoid the laborious job of cleaning the screen and to increase condenser efficiency.

Screens of stationary or of traveling type are installed in the intake water channel to prevent injurious small substances, such as grass, leaves, twigs, sea weed or fish from reaching the condenser and greatly impairing its efficiency or necessitating frequent cleaning of the condenser water surfaces. The stationary type of screen requires manual cleaning and removal of the refuse, which is a disagreeable task and likely to be slighted, unless well supervised.

Except in quite small power plants, the traveling type of screen is better used. It collects, elevates and disposes of the refuse, its screening surfaces being automatically cleaned by sprays of water, which, with the refuse, falls into a sluiceway. By simply starting the motors which drive the spray water pump and the screen, the refuse can be quickly removed. Thus, as the screening surfaces travel, clean unobstructed surfaces are presented in the intake.

Usually the traveling screen is run a short time at infrequent intervals, as its screening surfaces are quickly cleaned; during floods, however, in autumn when leaves are falling, during certain stages of ocean tide, or when needle ice is forming, it may be necessary to run the screen frequently, or even continuously.

When the traveling water screen is used, flood and

*Chief Engineer, Link-Belt Co.

FIG. 1. WATER INTAKE SCREENS AT CRAWFORD AVE. STATION

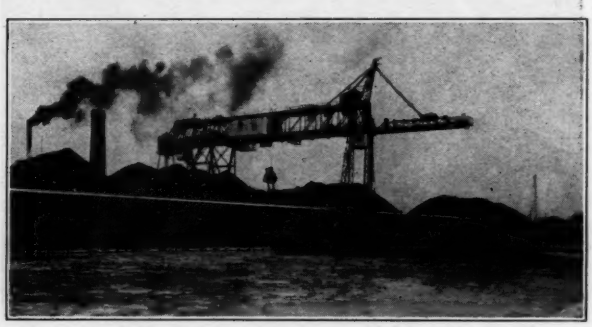


FIG. 2. TROLLEY BRIDGE FOR UNLOADING COAL BARGES, RACINE, WIS.

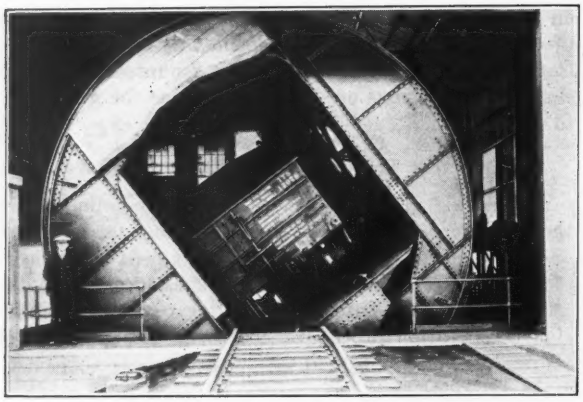


FIG. 3. LINK-BELT CAR DUMPER AT STATE LINE STATION

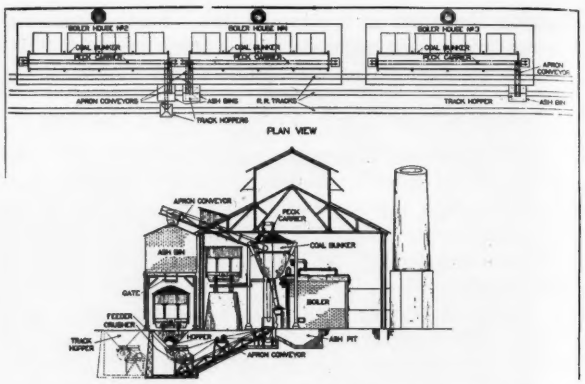


FIG. 4. COAL AND ASH HANDLING AT ROEBLING, N. J.

tide emergencies are handled without confusion, anxiety, additional attendants, or delay due to failure or impairment of condenser water supply. Every engineer who has had to rely upon the manually-cleaned stationary screen, will recall the anxious hours spent in maintaining condenser water supply.

An important consideration is that much smaller screen cloth openings may be used with the traveling than with the stationary type, because of the ease and dispatch with which the screen openings may be cleaned and the refuse removed.

Coal Handling Tools

Invariably, coal is delivered to its destination by water or by rail.

Ordinarily, water-borne coal, arriving in vessels is removed by claim shell buckets, which are hoisted and dumped direct into storage, or into a hopper whence it is conveyed to bunkers located in front of and above the boilers. The buckets are operated from hoisting towers, or bridges, of either stationary or traveling type.

At power houses which receive their coal in railroad cars, the coal may be shoveled by hand over the side of the car, but it seldom is, as this method is too slow and expensive, demurrage is high and it is wasteful to use man power which can be employed to better advantage for other purposes. This method of unloading cars is in the same category as the hand firing of boilers.

Car Unloading

Since the bottom-dump railroad car is now ordinarily procurable, it is customary to dump part or all of a car's contents into a hopper, located under the coal supply track, a satisfactory method when bottom dump cars are available, when adequate trackage and switch-

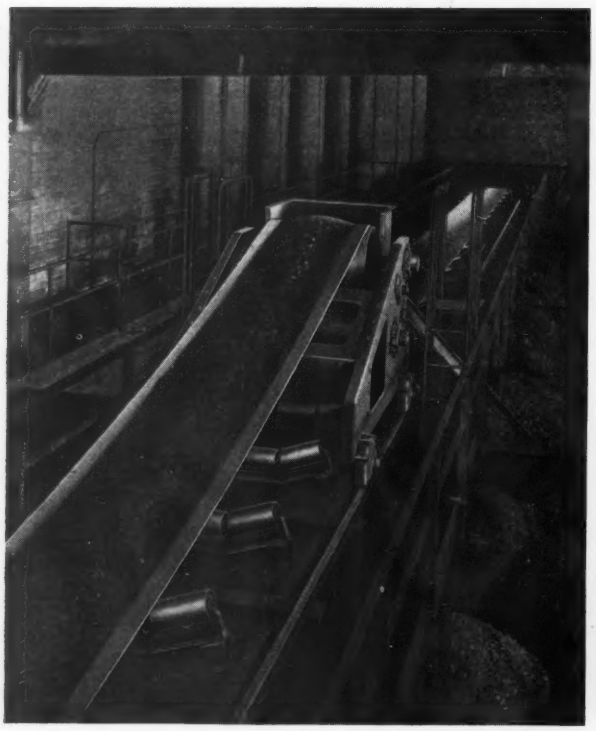


FIG. 5A. LINK-BELT CONVEYOR AND TRIPPER UNLOADER SUPPLYING COAL BUNKER

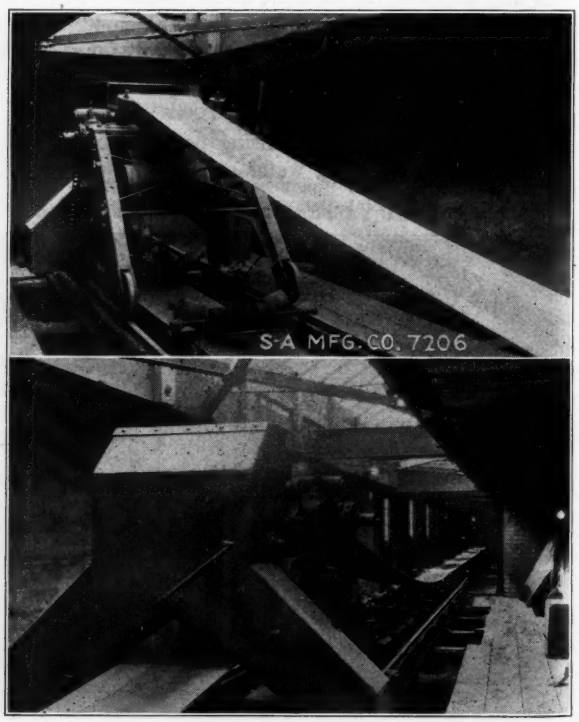


FIG. 5. STEPHENS-ADAMSON BELT CONVEYOR AND UNLOADING TRIPPER

ing facilities are provided, when the coal is not partially frozen in the cars and when not more than 300 to 400 t. of coal is to be unloaded during a period of eight hours. The dump car and track hopper are by no means an altogether satisfactory combination, hence are largely used only by plants which consume too little fuel to warrant the larger investment required to install better methods.

This is the day of big things, large corporations, super power houses, reduced power costs, even with the ever-increasing cost of labor, fuel, freight rates and materials of every kind. The large or super power house must unload its coal quickly and cheaply. There must be no shortage of fuel, even though shipments be delayed, coal be partially frozen in the cars, or dump bottom cars be unobtainable. To meet all these troublesome conditions, the rotary railroad car dumper was developed, which overturns and discharges the contents of the smallest or largest open top car of any type, within two minutes when desired. The gondola car dumper needs to be and is a more dependable tool than the boilers, generators or practically any of the other boiler house equipment, since it is never installed in duplicate, as are the other units. A single dumper and its operator will dump more cars in a given time than can be emptied into a number of large track hoppers under several tracks by a considerable force of men, with a minimum cost per ton and with a smaller original investment and maintenance expense. The rotary railroad car dumper for unloading coal plays as important a part as the modern stoker, boiler or steam turbine, in the economical generation of electric current.

Coal Elevating and Conveying Tools

Since coal crushing and pulverizing equipment is heavy and requires substantial foundations, it is, in practically every case, located at or near the ground level. Therefore, the crushed product must be elevated and conveyed to the overhead storage bunker to be drawn off as required by the stokers, by the direct-fired pulverized-firing system, or by the central pulverizing system when pulverized coal is stored.

For the quite small plant, which can support only a small investment in equipment, the centrifugal elevator fulfills well the purpose of elevating and discharging the coal into the storage bin.

When coal handling requirements are fairly small, the continuous bucket elevator is preferable to the centrifugal type and, if the overhead storage bin extends in front of several batteries of boilers, the elevator is supplemented by a scraper conveyor, which distributes the coal along the entire length of the bin.

Medium-size boiler houses may be provided with several types of equipment, the selection of which depends largely upon the surrounding conditions, such as location of track upon which coal is received, location available or desirable for storage bunker and whether the coal and ash may be advantageously conveyed and dumped into their respective storage bins by the same system. The leading types are: Pivoted bucket carrier, belt conveyor, skip hoist.

Pivoted Bucket Carrier

Probably the overlapping pivoted bucket carrier is the most universally used and applicable type of conveying equipment for serving the medium-sized plant, as it performs the several functions of receiving both the coal and ashes, separately of course, in its lower run, conveying the material to one end of the boiler house, elevating it and then conveying it to the overhead coal or ash bunker, where the contents of the buckets are dumped and distributed. This carrier is specially constructed to handle either coal or ashes, or both. As it always carries its load in malleable buckets, joined by substantial links provided with case-hardened steel bushings and pins and supported on large diameter enclosed-oiling, chilled-tread rollers, to carry them along at a very slow speed, its maintenance cost is low and dependability high. After 30 yr., it is still a leading type for handling coal and ashes, within its range of capacity and height.

Belt Conveyors

Large and super power houses require large capacity and high lifts. The belt conveyor and skip hoist types of coal handling equipment are almost universally used to meet these exacting requirements.

When the coal supply track is located so as to permit a belt conveyor to attain sufficient height before reaching the boiler house, to enable it to pass over the storage bunker and distribute its load to that bunker by means of a tripper, the belt conveyor makes an excellent selection. The principal elements of the belt conveyor, the rubber belt, the belt-carrying idlers and the individual rolls, have been so greatly improved within the last five years, that its use is preferable to that of the skip hoist, where sufficient space is available for its installation. Belt conveyor idler rolls are almost universally provided with antifriction bearings, requiring but infrequent lubrication and insuring maximum dependability and efficiency. Driving machinery should have antifriction bearings and speed reduction gearing enclosed in dust-tight housings, with the gears running in a bath of oil. All shafts and the belt pulleys should be of large diameter.

For distributing the coal to the large overhead bunker, which should contain a supply for at least a 24-hr. maximum boiler demand, the belt conveyor is provided with a traveling tripper of the automatic or semiautomatic type. Preferably, the tripper should have antifriction bearings, large shafts and pulleys and its traveling mechanism driven by an independent motor, direct-connected to an efficient speed reducer mounted on the tripper frame. This type of drive is superior to the type driven from the conveyor belt, which requires troublesome gearing, clutches and reversing mechanism.

Inasmuch as "operating viscosity" of lubricants plays an important part in the matter of high temperature lubrication, a detailed knowledge of viscosity in general is advisable. Just what is meant by the statement that an oil should have a viscosity of say 500 sec. Saybolt at 100 deg. F. will be vague to many. This means, however, that at a uniform temperature of 100 deg. F. it will take 60 c.c. of the oil 500 sec. to flow through an orifice of a standard Saybolt viscometer.

Volumetric efficiency of a pump or compressor is the actual discharge per minute divided by the theoretical displacement.

Power from Process and Space Heating Steam

PART II. HEATING WATER FOR PROCESS WORK BY MEANS OF A CONDENSING BLEEDER TURBINE OFFERS ADVANTAGES IN MANY PLANTS. BY L. A. HARDING*

WHEN A CONSIDERABLE PERCENTAGE of the total process steam is required for heating water, the most economical method of obtaining this hot water is from the condenser cooling water of a bleeder or extraction type turbine. The bleeder steam is extracted or drawn from the turbine at the pressure stage desired, while the steam required for the water heating is passed on through the low-pressure stages of the turbine to the condenser.

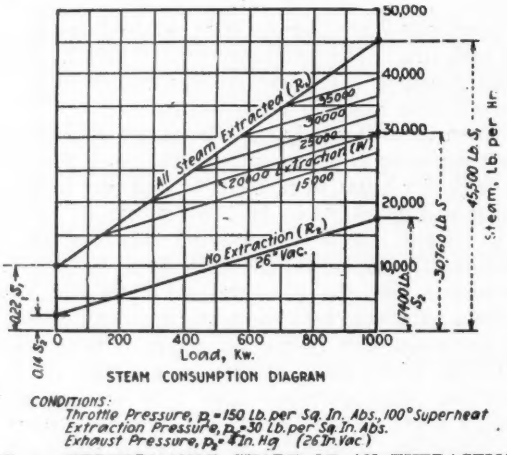


FIG. 1. PERFORMANCE CHART OF AN EXTRACTION TURBINE

For all practical purposes, the same weight of steam will be required to heat a given weight of water either at the extraction pressure or the condensing pressure. The temperature of the condenser hot well water is assumed the same as the temperature of the hot water employed in the process.

A difference in temperature exists between the temperature of the steam corresponding to the condenser vacuum and the hot well temperature (terminal difference) from 5 deg. to 15 deg., so that the temperature corresponding to the partial vacuum will be approximately 10 deg. higher than the hot well temperature. The absolute pressure corresponding to this temperature is, of course, the exhaust pressure for the turbine.

The following example illustrates the employment of an extraction type turbine for this purpose: Required the electric power that can be generated when the process steam requirement is 20,000 lb. per hr. (extraction) at 30 lb. per sq. in. absolute pressure and the hot water requirement is 211,000 lb. per hr. at 116 deg. F. The initial temperature of the water is assumed to be 65 deg. F.

To heat this amount of water per hour requires

$$(211{,}000 \times (116 - 65) \div 1000 = 10{,}760 \text{ lb.}$$

of steam per hour (latent heat assumed to be 1000 B.t.u. per lb.). This is the amount of steam to be passed through the low-pressure stages of turbine to the condenser. The total steam available for power generation is S = 20,000 + 10,760 = 30,760 lb. per hr.

Initial condition (P_1) of the steam at the throttle valve is assumed as 150 lb. per sq. in. abs., 100 deg. superheat as located on the Mollier chart at a, Fig. 2. The pressure drop across the throttle is assumed as 15 lb. per sq. in. so that steam enters the first stage of turbine at 135 lb. per sq. in. abs. with 102 deg. superheat located at a'.

TURBINE EFFICIENCY

Temperature of the hot water required is 116 deg. F. and assuming a 10 deg. terminal difference, the final steam temperature will be 126 deg. F. If any appreciable loss in temperature occurs in the hot water piping between the hot well storage and the point where the

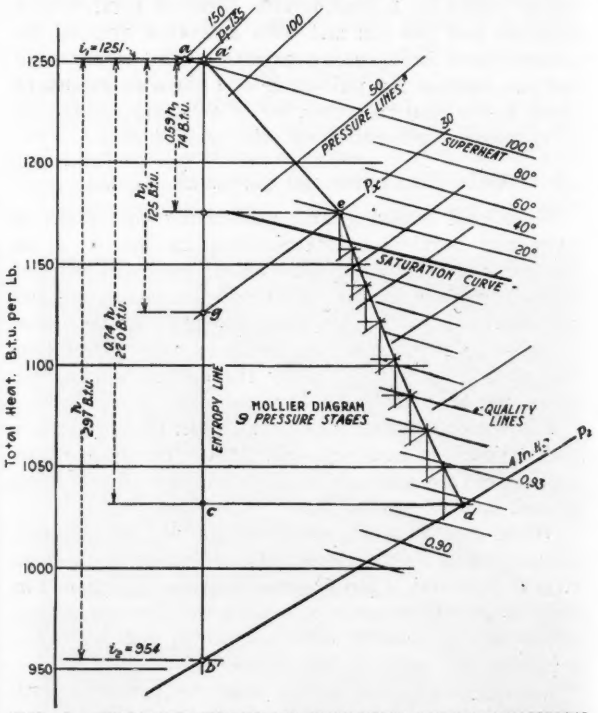


FIG. 2. MOLLIER DIAGRAM SHOWING THE EXPANSION LINE OF A MULTI STAGE TURBINE

water is required for use, the loss may be made up by bypassing the required amount of process steam into the hot well. The temperature (126 deg.) corresponds to an absolute pressure (p_2) of 4-in. mercury (or 26 in. vacuum referred to a 30-in. barometer).

Pass downward on the constant entropy line to the intersection b' with the 4-in. pressure line. The length of the line a' — b' represents the available energy h or 297 B.t.u. per lb. of steam for adiabatic expansion be-

*President, L. A. Harding Construction Co., Buffalo, N. Y. From a paper presented before the A. S. H. & V. E. Part I of this paper appeared on page 277 of the March 1, 1930 issue.

tween the pressure (p_1) = 135 sq. in. and (p_2) = 2 lb. per sq. in. It is possible to convert only a certain percentage ($\emptyset_t$) of the available energy into work delivered by turbine shaft, which in this example is assumed as 0.70 for the complete turbine. The mechanical efficiency $\emptyset_m$ is assumed as 0.94. The internal efficiency $\emptyset_1$ is therefore 0.70 ÷ 0.94 = 0.74 for complete turbine. The heat converted into work by the rotors is then 0.74 (h) or 220 B.t.u. as represented by the length of line a — c to scale. The length c — b′ to scale represents the heat per pound of steam used to raise the quality of the steam.

A horizontal line through c intersects the pressure line p_2 at d which gives a quality of steam to the condenser of 0.917. The stage efficiency of the high pressure end of the turbine will be considerably less than that of the whole machine as previously indicated. A nine-stage multicellular turbine is here assumed to be employed with a Curtis type high-pressure stage operating between an initial pressure of 135 lb. per sq. in. abs. and a terminal (bleeder) pressure of 30 lb. per sq. in. abs. The available energy (h_1) by the expanding steam between the initial condition and 30 lb. abs. bleeder pressure is 125 B.t.u. per lb. (a′ — g).

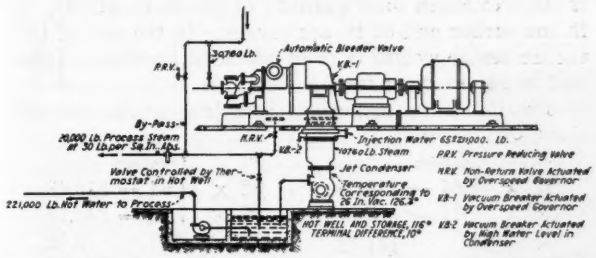

Automatic Bleeder Valve
V.B.-1
P.R.V.
By-Pass
Injection Water
Rated Lb. Steam
V.B.-2
Jet Condenser
Temperature Corresponding to 26 In. Vac. 126.3°
Valve Controlled by Thermostat in Hot Well
221,000 Lb. Hot Water to Process
HOT WELL AND STORAGE, 116° TERMINAL DIFFERENCE, 10°
P.R.V. Pressure Reducing Valve
N.R.V. Non-Return Valve Actuated by Overspeed Governor
V.B.-1 Vacuum Breaker Actuated by Overspeed Governor
V.B.-2 Vacuum Breaker Actuated by High Water Level in Condenser

FIG. 3. EXTRACTION TURBINE OPERATING CONDENSING (JET CONDENSER) AND SUPPLYING STEAM AND HOT WATER TO PROCESS

Chart Shows Operation for All Conditions

A Willans line chart similar to Fig. 1, may be constructed for determining the equivalent amount of electric power that may be generated from a bleeder type turbine at various ratings as follows: The water rate for the complete turbine when developing full load (1000 kw.) assuming $\emptyset_g$ = 0.945 and $\emptyset_m$ = 0.94 is:

$$EWR_{kw} = \frac{2546 \times 1.34}{220 \times 0.94 \times 0.945} = 17.4 \text{ lb. per kw-hr.}$$

Total steam for full load is therefore 17,400 lb. per hr. The no load steam will be approximately 0.14 × 17,400 = 2436 lb. The total steam line for no extraction is drawn on the chart as indicated.

When the turbine is operating all extraction, the high-pressure element only is employed in generating power. Assuming $\emptyset_t \times \emptyset_g$ = 0.60, the water rate for full load is (2546 × 1.34) (0.60 × 125) = 45.5 lb. per kw-hr. and the total steam required is 45,500 lb. per hr.

No load steam is assumed as 0.22 × 45,500 = 10,010 lb. per hr. and the Willans line drawn accordingly. The condition line shown on the Mollier chart represents the condition of the steam when the turbine is developing full load with 20,000 lb. per hr. extracted. The total steam passing through the high-pressure end of the turbine at this time is 30,760 lb. per hr. which develops 584 kw. as determined by the Willans line. The water rate for this condition of operation is therefore, 30,760 ÷ 584 = 52.6 lb. per kw-hr.

Stage efficiency for the high-pressure element for this condition of operation is determined from the following relation:

Let R_1 = (S₁ — No load steam to high-pressure element) divided by full load kw. and R_2 = (S₂ — No load steam to the complete turbine) divided by full load kw.

Then R_1 = (45,500 — 10,000) ÷ 1000 = 35.49
and R_2 = (17,400 — 2436) ÷ 1000 = 14.96

The steam required per hour to develop full load for W lb. of steam extracted per hour is expressed by the following equation:

$$S = W + \frac{A - (\text{W-no load steam hi. pr. el.})}{R_1} \times R_2$$

in which
S = the weight of steam required in lb. per hr. to develop full load.
A = full load rating in kw.
W = weight of steam extracted in pounds per hr.
Then

$$S = 20{,}000 + \left\{ 1000 - \frac{20{,}000 - 10{,}010}{35.49} \right\} \times 14.96$$

= 30,760 lb. per hr.

The water rate for this condition of operation at full load is therefore: 30,760 ÷ 1000 = 30.8 lb. per kw.

Any other amount of extraction steam is calculated and the corresponding total steam per hour line drawn as indicated above. Extraction lines for 15,000, 20,000, 25,000, 30,000 and 35,000 lb. of steam per hour are drawn parallel with the Willans line for no extraction as shown in Fig. 1. The extraction lines shown assumes a constant generator efficiency. These lines may be corrected for the decreasing generator efficiency as the load is reduced. Owing to approximately 8 per cent (0.917 quality) of moisture in the exhaust for 26 in. vacuum, approximately 8 per cent more steam must be passed to the condenser to heat the water required. This will increase, by approximately 8 per cent, the power generated in the low-pressure end of the turbine.

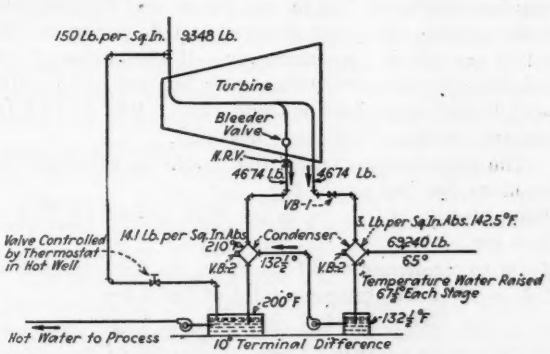


FIG. 4. EXTRACTION TURBINE ARRANGED FOR TWO STAGE WATER HEATING

Assuming the same amount of steam supplied a straight noncondensing one pressure stage turbine oper-

ating at the same initial pressure and superheat with 30 lb. abs. back pressure, the amount of power generated would be approximately 584 kw. The increase in power that would be possible to develop by the condenser method, as outlined, over that of employing the process steam at 30 lb. absolute pressure to do the same work is evidently 1000 — 584 or 416 kw., a gain of approximately 70 per cent in power without any expenditure for additional fuel.

Two Stage Water Heaters

The previous example illustrates single stage water heating. A more economical method, Fig. 4, is to use two or more stages, employing a lower partial vacuum for the first stage and complete the heating by steam bled at a somewhat higher pressure. Assume the same initial pressure as for the previous problem with 15 lb. per sq. in. drop across the throttle and 69,240 lb. water per hr. to be heated from 65 to 200 deg. Dividing the temperature rise (135 deg.) equally between two stages, a rise of 67.5 deg. for each stage is obtained.

Steam required to heat the water is: $(69{,}240 \times 135 \div 1000 = 9348$ lb. per hr. or 4674 lb. per stage.

The temperature of the hot well for the final or second stage is 200 deg. and with a 10-deg. terminal difference gives 210 deg. for the steam temperature to the condenser. This corresponds to 14.1 lb. per sq. in. abs. pressure. The temperature of the hot well for the first stage is 200 — 67.5 = 132.5 deg. This is also the temperature of the injection water for the second-stage condenser.

With a 10-deg. terminal difference the steam temperature for the first stage is 132.5 + 10 = 142.5 deg., corresponding to a terminal pressure for the turbine of 3.1 lb. per sq. in. abs. The theoretical water rate for the complete turbine is 12.4 lb. per kw-hr. and for that part of the turbine delivering steam at 14.1 lb. per sq. in. abs. is 19.3 per kw-hr. Assuming overall efficiencies of 0.60 and 0.64 the expected water rates become 19.3 ÷ 0.60 = 32.1 (2nd stage heating) and 12.4 ÷ 0.64 = 19.4 for complete turbine (1st stage heating).

The approximate power that could be generated by two-stage heating would be:

Steam bled at 14.1 lb. sq. in. = 4674 divided by 32.1 = 145.6 kw.

Steam to condenser at 3.1 lb. sq. in. = 4674 divided by 19.4 = 240.9 kw. giving a total of 386.5 kw.

$$\frac{2546 \times 1.34}{\emptyset_x \times 0.94 \times 0.945 \times 125} = 52.5 \text{ or } \emptyset_s = 0.59$$

The condition of the bled steam leaving the turbine is found to have approximately 20 deg. of superheat.

If the single-stage heating was employed the power generated would be:

$$9348 \div 32.1 = 291.2 \text{ kw.}$$

The gain by two-stage heating is therefore 95.3 kw. or approximately 33 per cent over the single-stage method.

Calculating Air for Combustion

By Wallace H. Martin*

FOR A NUMBER OF YEARS, the writer has used a method of computing the weight of air per pound of fuel which appears to have some advantages over other methods. As in the case of other methods in use, it is based on the fact that in a mixture of gases the weight of each is proportional to the product of the percentage by volume and the molecular weight.

Orsat apparatus removes CO_2, O_2, and CO. The remainder is often considered to be nitrogen; however, nitrogen does not enter into the reaction and furthermore is not determined directly so its use in calculating air supplied is not entirely justified.

To illustrate the method: In a certain test using wood fuel, the analysis obtained was as follows:

CO_2	11.64 per cent
O	7.68 " "
CO	0.17 " "

Molecular weight of CO_2 is 44. Of these 44 weight units 12 are carbon and 32 are oxygen. In other words, if there exists in some quantity of gas 44 lb. of CO_2, 12 lb. are carbon and 32 lb. are oxygen. In the case of CO, the molecular weight is 28 of which 12 parts are carbon and 16 parts oxygen.

Details of the method of carrying out the calculations are:

Carbon	Oxygen
$12 \times 11.64 = 139.68$	$32 \times 11.64 = 372.48$
$12 \times 0.17 = 2.04$	$32 \times 7.68 = 245.76$
141.72	$16 \times 0.17 = 2.72$
	620.96

In a quantity of gas containing 141.72 lb. of carbon there are 620.96 lb. of oxygen. The pounds of oxygen per pound of carbon ratio is then obtained by dividing 620.96 by 141.72 and is equal to 4.38.

On the dry basis was the analysis of this fuel:

Carbon	50.36 per cent
Hydrogen	5.92 " "
Oxygen	43.39 " "
Nitrogen	.05 " "
Ash	.28 " "

Carbon in the ash was so small as to be negligible consequently all the carbon in the fuel must have been in the chimney gas. The oxygen used to burn the carbon per pound of dry fuel is 4.38 × 0.5036 or 2.2 lb.

There is nearly enough oxygen in the fuel to satisfy the requirements for burning hydrogen.

Oxygen required = $0.0592 \times 8 = H \times$ mol. wt. = 0.4736 lb.

Amount already in fuel = 0.4339

Amount to be supplied by air = 0.0397 or say 0.04 lb.

Total oxygen per pound of dry fuel then is 2.2 × 0.04 or 2.24 lb.

Since there are 0.23 lb. of oxygen in 1 pound of air, the pounds of air per pound of fuel are 2.24 divided by 0.23, or 9.73 lb.

Theoretical requirements can be calculated as follows:

$(32 \div 12) \times 0.5036 + 0.04 = 1.34 + 0.04 = 1.38$ lb. oxygen per pound of dry fuel.

$1.38 \div 0.236 = 6$ lb. of air per pound of dry fuel

Excess air = 9.73 — 6 = 3.73 lb. per pound of dry fuel, or

$= (3.73 \div 6) \times 100 = 62.2$ per cent

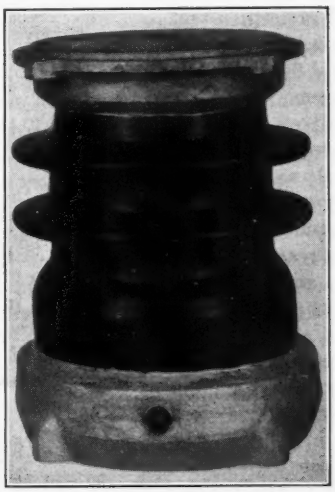
It will be observed that the calculation has been made without resort to anything except values actually determined in the gas analysis and without the use of mathematics beyond simple arithmetic.

*Professor of Heat Engineering, Oregon State Agriculture College, Corvallis, Ore.

Thyrite — *A New Material for* Lightning Arresters

New material developed by the General Electric Co. Engineers has properties of both a good conductor as well as insulator. Resistance decreases with voltage.

HAVING PROPERTIES THAT make it at once both a good insulator and a good conductor, a new material called thyrite created great interest at the recent winter convention of the American Institute of Electrical Engineers in New York. This material was announced by K. B. McEachron of the General Electric Co. in a paper which described its use for lightning arresters.



Thyrite, meaning gate or valve, has the remarkable property of changing its resistance to the flow of electricity as the voltage or pressure is changed. This change in resistance is such that each time the applied voltage is doubled the resistance decreases so that the current flow is increased more than 12 times. This means that if the voltage is increased 16 times the current flow is increased *25,000 times.*

Such properties make this material ideally suited for lightning arresters, for the ideal arrester may be defined as one which passes zero current as the applied potential is increased until the critical discharge voltage, set by the designer, is reached, when current begins to flow in whatever amount is needed to hold the potential across the arrester constant at the initial discharge valve. The current ceases when the applied potential drops below the critical value for the arrester. The critical voltage for such an arrester (we are still considering the *ideal* arrester) should be unaffected by the rate of voltage application, in other words, it should have no time lag.

A search for such a material having the properties which would approach the required properties of the ideal arrester was begun in 1923 and the paper by Mr. McEachron was the first public announcement of the results of that work. A material has been developed having mechanical properties somewhat similar to those of dry process porcelain, but possessing the remarkable property of being substantially an insulator at one potential and a good conductor at certain higher potentials. This material, thyrite, represents a new class of conductor which covers the middle ground between the insulator and the conductor.

In Fig. 1 are plotted the EI and RI characteristics for a six-inch thyrite disk for which a = 0.72 and C = 580 respectively. When considering the application of thyrite, it should be noted that the constant varies directly as the thickness of the piece but not inversely with the area as does the ordinary resistance. For instance, with an exponent of one, the constant for the piece depends upon the length but is independent of the area. To make this clear, we may consider the effect of doubling the area, remembering that the constant is defined as the resistance at one ampere, which, with an exponent of one, is inversely proportional to the current. By doubling the area, the current in the original area is reduced to one-half, but the resistance of each half is thereby doubled so that the total resistance remains unchanged. It should be noted that those relationships are dependent upon the definition of the "constant" as the resistance at one ampere. As the exponent approaches zero as a limit, these relationships approach those of the ordinary resistor.

It is interesting to note the wide range over which the change of resistance with current takes place, the available data showing that the law holds over current ratios of 10,000,000 to one. Each time the voltage is doubled the current increases 12.6 times for thyrite with an exponent of 0.72, thus if the potential increases 16 times the current increases 25,000 times.

Time Lag

Although thyrite may possess time lag, yet up to the present time the tests made have not disclosed its existence. One of the best illustrations of this characteristic is shown in Fig. 2, which shows test results taken on 90 disks connected in series. The characteristic of each disk was first determined with direct current using a potentiometer up to 0.1 amp. The exponent for the entire stack was found to be 0.7 and the constant 500 per disk. The whole stack was next tested with alternating current with sufficient potential so that a crest current of nearly four amperes flowed through the stack.

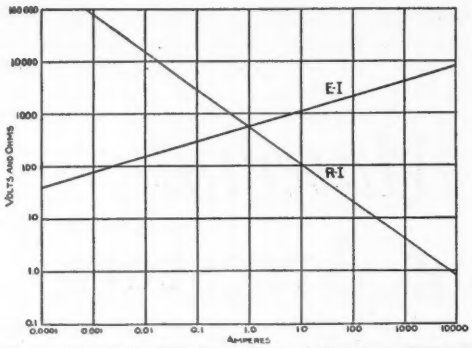


FIG. 1. CHARACTERISTIC E. I. AND R. I. CURVES
For a thyrite disk and 6 in. diameter

Oscillograms were taken and the instantaneous resistance calculated and the results are plotted as in Fig. 2. The stack of disks was then tested with a million-volt impulse generator, the current being determined by the voltage drop across a series water tube. The voltages were determined by sphere-gap measurement. These results are also given in Fig. 3 and fall on the same straight line as the data taken with alternating current and direct current. That the results fall so nicely on the same characteristic with such widely varying wave front shows clearly that no measurable time lag exists. That there should be no time lag seems reasonable for the material always acts as a resistance, and its operation does not depend on any arcs or sparks or the breakdown of any dielectric.

A large amount of other data has been taken since that shown in Fig. 2, in which the cathode ray oscillograph has drawn the volt-ampere curve. These data have always fallen on the same straight line as the characteristics obtained on the same piece with direct current, so that today the men working in the laboratory with this material under transient conditions, trust its faithful performance of its characteristic as much as they would the performance of a piece of nichrome wire or other similar resistor.

Operation on Alternating Current

Since the current varies as the $\frac{1}{1-a}$ power of the voltages, with an exponent 0.72 the current will vary as the 3.57 power of the voltage. With a sine wave of applied potential, the current wave will not be a sine wave. An oscillogram showing the wave form of the current is given in Fig. 3. In case the potential wave contains tooth ripples, these will be greatly magnified on the crest of the current waves. It should be noted that the current wave is perfectly symmetrical, illustrating the fidelity of the material whether the current is increasing or decreasing. As will be seen later, this is just as true for an impulse lasting but a few millionths of a second.

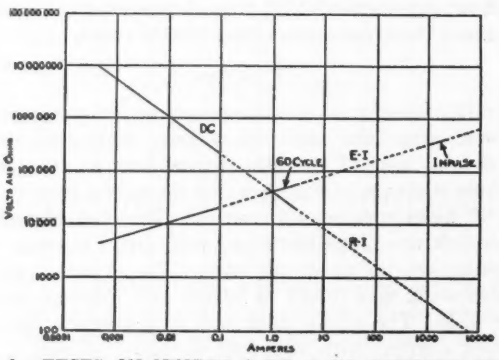


FIG. 2. TESTS ON NINETY 6 BY ¾-IN. THYRITE DISKS
With a.c. and d.c. impulse

Because the current wave is not a sine wave, it is desirable always to speak of both the voltage and current in terms of actual instantaneous values and not effective values. Thus, with the ordinary resistor, one may find the corresponding current from either the effective or the crest voltage, but with thyrite, if the potential is given in effective volts it must always be changed to crest volts and the crest current found. If energy loss in the piece with an applied sine wave voltage is desired, the product of the crest voltage and the crest current is to be multiplied by a factor taken for the particular exponent possessed by the piece.

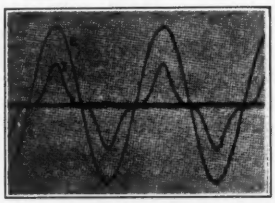


FIG. 3. OSCILLOGRAM SHOWING WAVE FORM OF CURRENT PRODUCED BY A SINE WAVE VOLTAGE

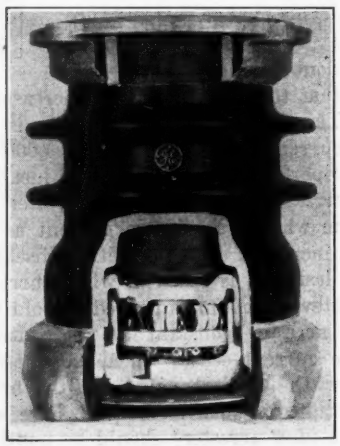


FIG. 4. SECTIONAL VIEW OF 11,500-V. THYRITE LIGHTNING ARRESTER UNIT

An increase in temperature of thyrite tends to lower its resistance but for ordinary changes in temperature of an arrester, the effect of the resistance is small. When cold, the original values of resistance reappear.

Several samples of the first thyrite made have been on life test for more than five years, and tests at frequent intervals have shown the characteristics to be practically unchanged.

It seems then that a material having the proper characteristics for lightning arresters has been found. It has the desirable hyperbolic characteristics, not to a

degree indicated in the ideal arrester where the exponent is one, but sufficiently so that it may be used successfully. It has no measurable time lag and is durable. Its characteristics are permanent and not affected by use.

The Arrester

In designing lightning arresters for all voltage ratings, it is worth while to build them in the form of standard units which will all be alike, various numbers being used to correspond to the different ratings. This will greatly simplify manufacturing and stocking the arresters. For certain conditions, it may be necessary to

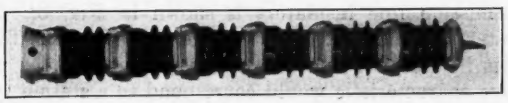


FIG. 5. 69,000-V. THYRITE LIGHTNING ARRESTER, STATION TYPE

supply smaller or part units, and this applies particularly to the lower voltages. The standard unit is rated 11.5 kv. grounded neutral. Thus for a system rated 115 kv. with a solidly grounded neutral ten units would be used. The arrester does not employ a series gap, each unit being complete within itself and containing its own gap structure. On page 389 is shown a single unit and Fig. 5 six in series, such as would be used on 69-kv. grounded neutral. Figure 4 is a sectional view of one unit. No steel work is required for the 69-kv. arrester. The units should be mounted on a concrete foundation to keep clear from weeds, snow, etc.

Performance Characteristics

For the first time in the history of lightning protection, it becomes possible to calculate arrester performance accurately. The volt curve ampere for the 11.5 kv. unit is given in Fig. 6 and is the curve for eleven, six-inch disks in series, making a total height of 8¼ in. In this design the disks are coated with copper on both sides by the Schoop process and stacked up inside the porcelain container. It is necessary to use a series gap arrangement which is housed in each 11.5-kv. container.

The reason for the series gap will be apparent from an examination of the characteristic curve. The normal voltage to ground is 9.4 kv. crest, which would cause a steady current of four amperes crest to flow through the arrester continuously. If an over-voltage is applied as may occur in the case of dropping a load and overspeeding generators, a potential as high as 16.2 kv. may be applied between line and ground. With this potential a current of 28 amperes would flow and thus, for safe operation, it is necessary that the gap be capable of stopping the flow of current after one-half cycle, even if the impressed potential is 16.2 kv. and the current 28 amperes. A single arrester gap is unable to break an arc of this magnitude and it is therefore necessary to break the single gap up into a series of small gaps, which possess the property of quenching an arc if the voltage distribution across the gaps is such that the potential per gap is kept small. Because of the necessity of introducing several small gaps in series two opposing conditions develop. With a 60-cycle voltage applied, the distribution of potential between the gaps must be kept uniform, otherwise spitting would occur, which not only would set up radio interference, but would make impossible the operation of the arrester with several units in series, with several gaps in each unit. At the same time, unless some means could be found to upset the uniform distribution under impulse conditions, the arrester breakdown would be too high for satisfactory protection. Fortunately, this problem has been solved so that a uniform distribution is obtained with the application of system potential but the distribution becomes non-uniform when a steep wave front of potential is applied. Thus the impulse ratio is kept close to one, as for example, the breakdown of the series gap at system frequency is about 35-kv. crest, while with the application of an impulse requiring one microsecond to reach breakdown it is about 45-kv. crest. Thus for currents up to 1000 amp. the arrester unit holds the voltage to a value not in excess of 2.8 times its rating.

From the curve, Fig. 6, it may be seen that 45 kv. corresponds to a current of about 1000 amp., so that for discharges involving currents smaller than 1000 amperes the gap breakdown represents the limiting potential, while for currents in excess of 1000 amperes the *IR* drop represents the maximum applied to nearby insulation in parallel with the arrester. Cathode ray oscillograms taken on a complete 11.5-kv. unit are given in Fig. 7. It should be noted that in this illustration the volt-ampere curve shows no loop, the increasing and decreasing characteristics following the same curve. The

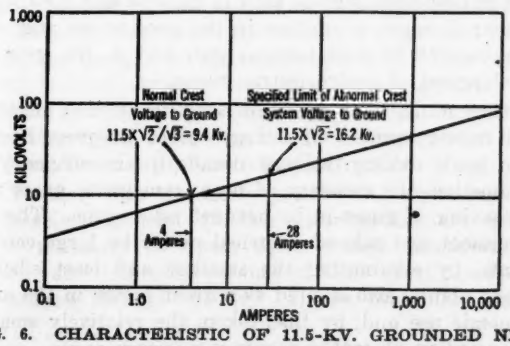


FIG. 6. CHARACTERISTIC OF 11.5-KV. GROUNDED NEUTRAL THYRITE LIGHTNING ARRESTER

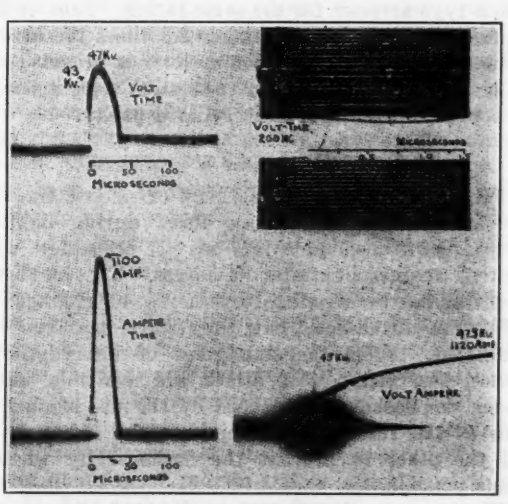


FIG. 7. PROTECTIVE CHARACTERISTICS OF 11.5-KV. THYRITE LIGHTNING ARRESTER

close agreement between this volt ampere curve and the curve of Fig. 7, illustrates how accurately the arrester characteristics can be determined.

The Arrester Unit

The arrester unit for 11.5-kv. grounded neutral service as designed at present is 14½ in. high and 12 in. in diameter. It weighs about 100 lb. The unit is sealed, as no venting is necessary with this new arrester. If it is desired to check the arrester's characteristic this can be done by the use of the ordinary oscillograph. If arrangements are made to measure voltage and current by the use of the oscillograph, a few cycles of 60-cycle current can be made to pass through the arrester and from the oscillogram showing voltage and current the

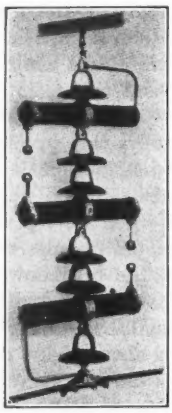


FIG. 8. 69,000-V. TRANSMISSION LINE LIGHTNING ARRESTER

arrester characteristic can be determined accurately. Such a test cannot be prolonged as the arrester would become hot and the series gaps would be burned.

Distribution Arrester

In the distribution arrester thyrite disks one inch thick and three inches in diameter are used. The 3-kv. arrester requires two disks in series. It has a volt-ampere characteristic designed to be similar to the station type arrester for the same rating. Thus at 1000 amperes the arrester potential is 2.8 times the arrester rating. Since the distribution arrester is provided with but one-fourth of the area of the station type, it has but one-fourth of the current carrying capacity.

Transmission Line Type Arrester

Probably the least reliable part of electric transmission is the transmission line itself during lightning storms. No transmission line has yet been built which is proof against lightning flashovers. The number of flashovers has been reduced by the use of ground wires and extra insulation, but they have not yet been eliminated. From the standpoint of interruption to service, two methods of attack are available, one to render the flashover innocuous by the use of such devices as the fused grading ring or the Peterson coil, and the other to prevent the flashover by whatever means possible.

The better method is to prevent the flashover and if possible at the same time absorb a considerable portion of the energy of the charged capacity of the line by the use of some device, such as a lightning arrester.

The idea of using arresters along a line is not new but suitable arresters have not been available either from the standpoint of size or cost.

The new arrester material will, it is believed, offer a means of protecting insulator strings on towers at a cost which is reasonable and it should greatly increase the reliability of transmission lines.

The problem is more definite than that of protecting station insulation, since the arrester is placed very close to the insulator string and both have the same ground.

An arrester using thyrite disks for the protection of transmission line insulators is shown in Fig. 8. The arrester shown is rated 69 kv. and uses 72 disks three inches in diameter and one inch thick, so that the protective characteristic would correspond to a station type rated 108-kv.

It is probable that experience will show that the number of disks can be reduced, which will improve the protection afforded and also reduce the cost of the arrester.

With such application of arresters, it is not necessary that the arrester have large discharge capacity, as several would operate in parallel. Whether or not such protection would eliminate flashovers due to direct strokes is not known. It is the intention to try out arresters of this character on at least two transmission lines this summer.

Increased Power Plant Efficiency Contributes to Coal Industry Depression

Keen competition between the different modern sources of fuel and power is reflected in an analysis of world energy production for the 15 yr. period 1913-1928, made by the National Industrial Conference Board. While the production of crude oil and of hydroelectric power, however, have increased by 243 and 162 per cent respectively and that of natural gas by 133 per cent, the 1928 world output of coal, although at present coal is still by far the most important source of energy, was only 5 per cent greater than that in 1913, world coal consumption having become practically stationary during recent years.

Depression of the industry in the older coal mining areas, such as has developed during post-war years, the Conference Board finds, has been due not to any one but to four major causes: 1, the increased output of useful energy per ton of coal; 2, increased coal production in new mining areas both in Europe and the United States; 3, rapid expansion in the production and consumption of oil and natural gas, and 4, the growing development of hydroelectric power.

Coal, thus, is as much in competition with itself as with newer sources of energy, great progress having been made during the past decade in the efficiency of combustion, the recovery of heat from waste gases and the saving of gases in by-product coke ovens. The development and sale of electrical power by large central plants, by eliminating the smallest and least efficient power plants, also is cited as a great factor in the more economic use and, by that token, the relatively smaller consumption of coal.

Electricity---What It Is and How It Acts*

PART XXXVII. THE NATURE OF THE RADIATIONS FROM RADIOACTIVE SUBSTANCES. COMPARISON OF THEIR PROPERTIES WITH THOSE PRODUCED ELECTRICALLY. BY A. W. KRAMER

THAT THE RADIATIONS emitted from radium and other radioactive substances are of a complex nature and consist, as was stated in the preceding article, of three different types was made manifest by the great difference in penetrating power of these types. This difference is very pronounced. It was discovered that a certain proportion of the total radiation was completely absorbed by very thin screens—even by a sheet of thin paper or by a few centimeters of air. These Rutherford called Alpha rays. A far more penetrating radiation, capable of passing through several millimeters of aluminum, were called Beta rays. A third type, subsequently called the Gamma rays, were found to be far more penetrating than even the Beta rays for their effect was not lost until they had to pass through as much as twenty centimeters of iron or several centimeters of lead.

The striking difference in the penetrating power of these three classes of radiation led the investigators to examine more carefully the nature of each of these classes. At first, it seems as if the feebly penetrating alpha rays were of little consequence. They were easily stopped by thin screens and their effects on the photographic plate was small in comparison with the effect of the beta rays. To the electrical test, that is the discharge of an electroscope, the alpha rays were immensely more effective than both the beta and gamma rays together, and from this fact Rutherford concluded that the energy possessed by these feebly penetrating alpha rays is always immensely greater than the other two types of radiations taken together. This conclusion has been borne out fully by subsequent researches. In fact, the beta and gamma rays at most possess but a few per cent of the total energy of radiation and are in this fundamental respect of less consequence than the previously neglected a class.

In Fig. 1 are shown two drawings made from actual photographs illustrating the electrical effect. At a is shown an electrified silk tassel suspended from an insulating support. The tassel has been stroked with a rubber tobacco pouch and is electrified. All threads having similar charges, they naturally repel each other and stand out as shown. Now, suppose, while the tassel is thus electrified, a capsule of radium bromide is placed on the table underneath the tassel. The moment this is done, the threads collapse as shown at B. This experiment is very striking and illustrates beautifully the ionizing power of the radium rays. From our previous consideration of X-rays we know, of course, that a beam of X-rays would produce a similar result.

To show that the feebly penetrating alpha rays are so largely responsible for this electrical discharge effect, it is necessary to touch upon certain considerations which come into play because of their great absorption in passing through matter.[1] In the first place, radioactivity is a mass or volume phenomenon. That is to say, every part, not the surface only but the inner portions also, of a radium salt, for example, is giving alpha beta and gamma rays. All of these rays are absorbed by the substance itself very considerably but this absorption does not affect the more penetrating rays (the beta and gamma) nearly so much as the feebly penetrating a rays. That part of the latter generated inside the salt does not escape at all. Only a very thin film contributes to alpha radiation. The consequence is that whereas with the small quantities of radium available for study the strength of the more penetrating rays is more or less proportional to the quantity of radium employed, for the alpha rays this is not the case. For

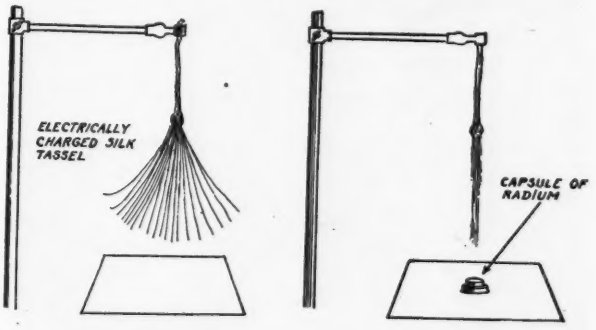


FIG. 1. DRAWINGS MADE FROM PHOTOGRAPHS SHOWING THE ELECTRICAL EFFECT OF RADIUM

At a is shown an electrified silk tassel. This has been rubbed with a rubber tobacco, pouch so that all threads are given similar charges; thus, they repel each other. At b is the same tassel after a capsule of radium has been placed underneath it. Due to the property which radium rays have of making the air conducting, the threads of the tassel have collapsed.

the alpha rays, the effect is proportional, not to the weight or mass of the substance available but rather to the amount of surface exposed. An exceedingly small quantity of radium bromide, spread out as a thin film on a large plate, will give immensely more a rays than the same quantity in the form of a crystal.

We have seen that to free the beta and gamma rays from the alpha rays it is merely necessary to interpose between the radium a screen of cardboard until the alpha rays are all screened out. The same, of course, applies to the separation of the beta from the gamma rays, only here the thickness of the screens will be greater.

It is evident, however, that in order to separate the alpha from the beta and gamma rays this method of separation does not apply, for any screen or filter which removes the beta and gamma rays removes much more readily the feebly penetrating alpha ray.

To separate the alpha rays, therefore, use is made of the surface phenomena referred to above. If a very minute quantity of radium salt is spread over a large area, the beta and gamma rays from so small a quantity will be practically negligible, whereas the alpha rays

*All rights reserved.
[1]The Interpretation of Radium by Soddy.

under these conditions will reach their greatest intensity. For practical purposes, this film of pure radium salt can be used to give alpha rays by themselves, essentially free from the beta and gamma rays.

To show the range of the alpha rays in air, Professor Bragg devised a very striking experiment which can be demonstrated in any laboratory possessing a small

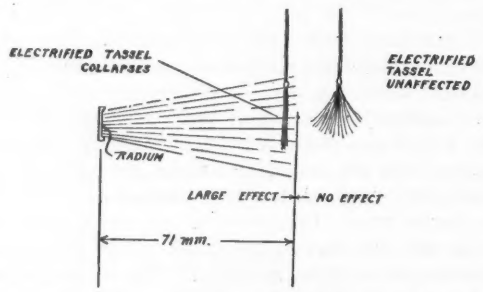


FIG. 2. SHOWING THE VERY DEFINITE RANGE OF THE ALPHA PARTICLES

Up to a distance of 71 mm. the intensity of action is quite strong but at this distance it ceases abruptly. The electrified tassel placed just beyond the distance is unaffected but when moved to just within this distance from the radium it collapses almost at once.

quantity of radium. The alpha rays, we have said, are stopped by a few centimeters of air—that is, they are absorbed entirely in passing through such a small thickness of air.

What is so striking about this experiment is not the fact that a small amount of air is sufficient to effect

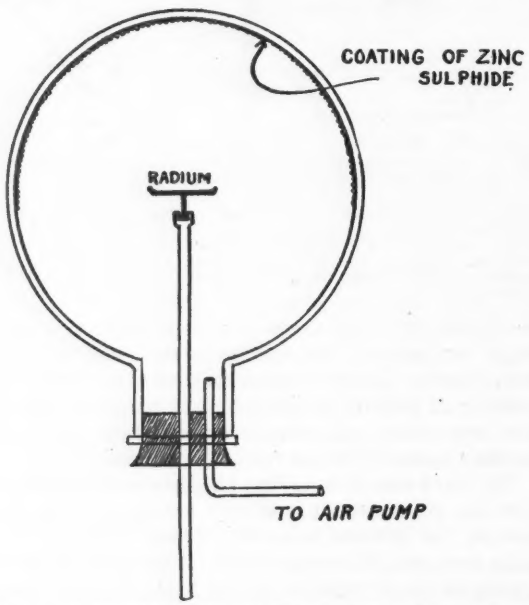


FIG. 3. AN EXPERIMENT TO SHOW THE RANGE OF THE ALPHA PARTICLE IN AIR

complete absorption, but the suddenness with which this effect occurs. Each individual alpha ray from any one radioactive element[2] travels exactly the same distance in an absorbing medium and is stopped sharply and completely when a certain thickness of matter has been penetrated. As a consequence, if we measure the effect of a homogenous beam of alpha rays just outside of the distance of complete absorption, there is absolutely no effect, while just within there is an extremely large or powerful effect. See Fig. 2.

In Fig. 3 is shown a diagram of a flask, slightly more than 6 in. in diameter and coated on the upper hemisphere of the inside surface with a phosphorescent film of zinc sulphide. This film prosphoresces brilliantly when exposed to the direct action of a beam of alpha rays. In this experiment the flask is so arranged that a platinum disk coated with an extremely thin layer of radium salt[3] can be moved upward inside the flask, the disk being held centrally by means of a cork.

Assume that the room is darkened. In the dark, the flask, being full of air at atmospheric pressure, can scarcely be observed; there is no glow. The three inches of air between the radium surface and the chemical coating on the inside of the flask entirely absorbs the

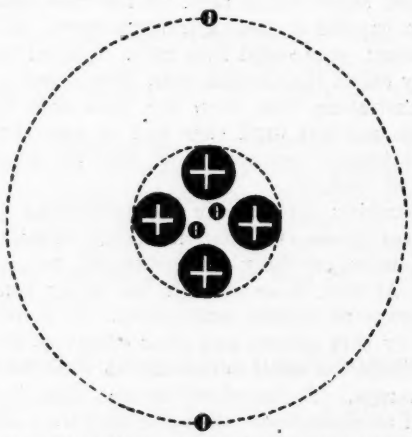


FIG. 4. DIAGRAM OF A NEUTRAL ATOM OF HELIUM

a rays and practically all of the beta and gamma rays of which there is only a negligible amount. It is only necessary, however, to connect the flask to an air pump and to commence to reduce the air pressure for the zinc sulphide film to start to glow. At the first stroke of the air pump, the whole globe flashes into luminescence and as the pressure is reduced, this luminescence become stronger. Due to the reduced air pressure, the alpha rays are now not subjected to so much absorption and the rays reach the surface of the globe. As soon as the air is readmitted, the luminescence ceases as suddenly as it appeared.

Thus it is seen that the range of alpha rays is something that is very definite. This peculiar property gives us a clue as to what these rays are, for it appears that this radiation is not subject to the same laws which govern the dispersion of light and X-rays. Today, after years of study and research we know that this is true; we know that at least two (the alpha and the beta rays) out of the three types of rays are not like light, but consist of excessively minute particles, traveling with immense velocity, as was the case with the cathode ray.[4] This is one of the chief lines of evidence that radioactivity is a manifestation of atomic disintegration, for these particles must be emitted at the expense of the material of the atoms themselves.

[2]There is a difference in the penetrating power of alpha rays from different radioactive materials. Thus, the range of the alpha ray of radium is different from the alpha ray of say thorium or uranium.

[3]Prepared by evaporating down a solution containing about a milligram of pure radium bromide.

[4]See chapter XV Electricity—What It Is and How It Acts, Vol. I.

Nature of the Alpha Rays

The alpha rays from all radioactive materials are the same except as to the speed at which they travel and consequently the range of action. These rays consist of material particles, identical in mass, and are actually charged atoms of helium projected with velocities of about 10,000 mi. per sec. This accounts for their definite range for since they all have the same mass, the distance which they can travel through a material which impedes their progress naturally is a direct function of their initial velocity. In some radioactive elements, the explosion, so to speak, which hurls them out from the atom is evidently considerably greater than in other elements. In the case of thorium C, for example, the range of the alpha particle in air is 8.62 cm. but in uranium I it is 2.7 cm. The explosive force responsible for the projection of the alpha particle from theorium C is considerably greater than it is in the case of uranium I, although the alpha particle itself is exactly the same in both cases. It consists of the nucleus of the helium atom.

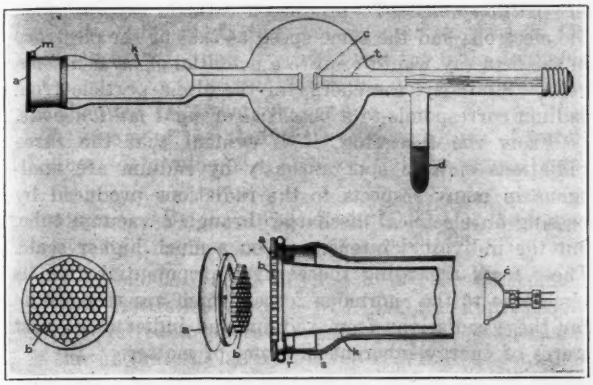


FIG. 5. DIAGRAM OF THE COOLIDGE CATHODE RAY TUBE DEVELOPED AT THE RESEARCH LABORATORY OF THE GENERAL ELECTRIC CO.

a, window or anode; b, hexagonal supporting grid; c, cathode cup; d, charcoal gas trap; k, copper anode shield; m, water cooling coil around anode; r, Invar anode sleeve; s, Invar-to-glass seal; t, cathode shield.

Now, the helium atom, it will be recalled, consists of the arrangement shown in Fig. 4, that is, of a central nucleus consisting of four protons and two electrons, and two external electrons. The alpha particle is identical with this arrangement except that the two external electrons are lacking. Because of this deficiency of external electrons, the a particle carries a positive electrical charge. An alpha particle, therefore, after it has been ejected from its parent radioactive substance, in order to become a normal atom of helium, must acquire two electrons and this it does in the ordinary course of events. So much for the a particle at this stage of the discussion.

The beta rays also have been shown to be particles but in this case the particles are electrons. Being of very much smaller mass than alpha particles they move at very much higher velocities. The beta ray, it will be evident, is much the same as the cathode ray produced in the vacuum tube. The cathode ray, it will be recalled, consisted of a stream of electrons moving at high velocities and now we find that the beta ray also consists of a stream of electrons in rapid motion, but the velocity of the beta particle is higher than that of the fastest known cathode ray, in fact, the velocity of the beta particle is greater than that of any other material particle.

In the ordinary vacuum tube the speed of the electrons is say from 5000 to 10,000 mi. per sec. while in radio transmitting tubes and X-ray tubes the speed acquired will reach as high as 30,000 to 40,000 mi. per sec. The speed of the beta particle, however, approaches the speed of light itself, the fastest of them traveling so nearly as fast as light as to be practically indistinguishable from it. Most of the beta particles, however, travel from 75,000 to 150,000 mi. per sec.

This enormous velocity of these beta particles or electrons is one of the most astonishing things about radium. In nature, the beta ray resembles greatly the cathode ray in the vacuum tube, yet a close study of its characteristics reveals a difference. By the use of exceedingly powerful electrical apparatus and the expenditure of a considerable energy, we can simulate the beta ray. At the research laboratory of the General Electric Co. in Schenectady, Dr. W. D. Coolidge, by placing three cathode ray tubes in series and impressing upon each one a voltage of 300,000 or a total of 900,000 v. across the three tubes, has succeeded in accelerating the electrons to a speed of 175,000 mi. per sec. This is well within the speed range of high velocity beta particles, but not of the highest.

FIG. 6. THE COOLIDGE CATHODE RAY TUBE IN WHICH UNDER A POTENTIAL OF 350,000-V. ELECTRONS ARE ACCELERATED TO A SPEED OF 150,000 MILES PER SECOND. PHOTO, COURTESY OF THE GENERAL ELECTRIC CO.

The manner is which this was accomplished is of considerable interest. A diagram of the Coolidge cathode ray tube is shown in Fig. 5. It consists of a tube similar to an X-ray tube, but instead of the tungsten target of the X-ray tube, the end of the tube is fitted with a window, 3 in. in diameter made of nickel foil a few thousandths of an inch thick, capable, however, of withstanding a total atmospheric pressure of more than 100 lb. Electrons evaporated thermionically from the tungsten filament are drawn across the inter-

vening space to the metal window under a potential of some 350,000 v. and are thus accelerated to an extremely high speed—approximately 150,000 mi. per sec. Striking the metal window at this speed they pass through it with but little diminution in velocity into the atmosphere. The thin piece of nickel serving as the window itself could not withstand the atmospheric pressure of 100 lb. (the difference between the outside air and the almost perfect vacuum inside the tube) so it is reinforced with a honeycomb structure of molybdenum.

If the tube is operated in a darkened room, a hum is heard and the window of the tube is seen to be surrounded by a ball of purplish haze, about two feet in diameter. This glow which shows the penetration of the cathode rays in air, results from the air being ionized or broken up by the rays of electrons.

By placing three such tubes in series, that is, by compelling the electrons projected from one tube to enter the next where they are further accelerated and

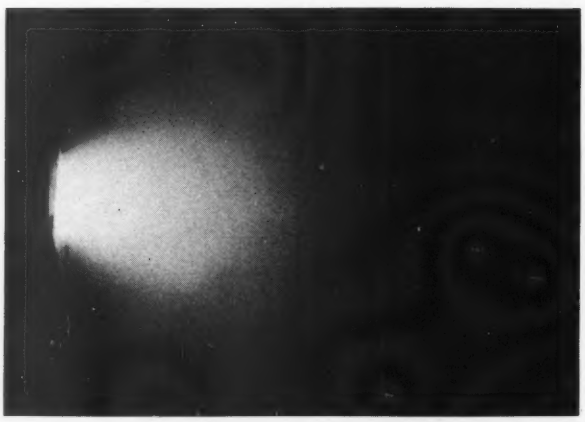


FIG. 7. A PURPLE HAZE SURROUNDS THE WINDOW OF THE CATHODE RAY TUBE WHEN IN OPERATION

This haze is due to the intense ionization and recombination of the atoms of the air. This ball of haze is sometimes as much as two feet in diameter depending upon the potential used on the tube. Photo, courtesy General Electric Co.

then finally to a third tube, Dr. Coolidge has been able to impart speeds of 175,000 mi. per sec. to the electron.

That such enormous velocities can be obtained even at the expense of a million volts drop in potential and complex vacuum tube equipment is remarkable, but in radium this thing occurs spontaneously—without noise, without disturbance!

The Gamma Ray

In the third type of radiation from radioactive materials, the gamma ray, we have a true X-ray of extremely penetrating character. The gamma ray consists of neither alpha particles nor electrons, but is a true electromagnetic radiation, similar in all respects to visible light and X-rays except that the frequencies are enormously higher than even the shortest X-rays we can produce by electrical means in the X-ray tube. Both the alpha particles and the beta particles can be deflected by a magnetic field, proving that they are electrically charged bodies, but the gamma ray is undeflected even by the most powerful fields. The frequencies of this radiation, as can be seen from the chart, in Part XXVI[5] are far greater than those of the average frequencies of X-rays and are in the neighborhood of 1019 vibrations per second.

It will be recalled that the frequency of X-rays produced in an X-ray tube is proportional to the speed at which the exciting electrons strike the target and this in turn is a function of the potential across the tube. The greater the potential, the higher will be the frequency of the resulting X-rays. The highest voltages used on X-ray tubes today is in the neighborhood of 250,000 v. To produce X-rays having the same frequency as that of the gamma ray, would require a potential of *at least two million volts*. To produce a cathode ray in which the electrons had the same speed as that of the electrons in the beta ray would require a potential of *three million volts*. Similarly, the energy of the alpha particle from radium corresponds to a potential of *eight million volts*.

From the foregoing, it is evident that the three radiations emitted spontaneously by radium are analogous in many respects to the radiations produced by passing an electrical discharge through a vacuum tube, but the individual intensity is on a much higher scale. These facts regarding the equivalent potential give us some clue to the enormous forces which are responsible for these radiations from radium and indicate the vast stores of energy inherent in atoms of matter.

[5]August 15, 1929, page 896.

In wood-working plants, a great deal of the power load is made up of exhauster fans which remove the sawdust and shavings from the machines to the cyclones. Size of connections will vary with the quantity of shavings, type and moisture content of the lumber and speed of the cutters. The main pipe will vary in diameter from the dead end, a good proportion being 25 per cent in excess of the sum of the branch pipe areas from the point in question to the dead end. Floor sweeps need not be included if provided with good blast gates.

Air velocities in planing mill work range from 2500 to 5000 ft. per min., depending upon the class of work. For dry wood, they will range up to 3000; for heavy shavings and sawdust, from 3000 to 4000 and for hog waste and pulp chips, up to 5000 ft. per min.

Sizes of mains should be determined only after considering which machines will operate simultaneously and it must be ascertained that at no time will the velocity be below the velocity which will carry the material; otherwise, the material will settle out and eventually clog the system. Sometimes it is necessary to use a much higher normal velocity to take care of periods when some of the machines are shut off.

Total production of soft coal during the week ending February 15, including lignite and coal coked at the mines, is estimated at 10,300,000 net tons, according to the latest report of the Bureau of Mines, Department of Commerce. Compared with the output in the preceding week, this shows a decrease of 636,000 t., or 5.8 per cent. Production during the week in 1929 corresponding with that of February 15 amounted to 11,941,000 t. Total production of Pennsylvania anthracite during the week ending February 15 is estimated at 1,737,000 net tons, a decrease of approximately 0.5 per cent from the output in the preceding week. Total production of by-product coke in January was 4,203,323 net tons and of beehive coke, 309,200 t.

Multiple Effect Refrigeration

DETERMINING THE POWER REQUIREMENTS OF A MULTIPLE EFFECT REFRIGERATION SYSTEM. BY N. H. HILLER, JR.*

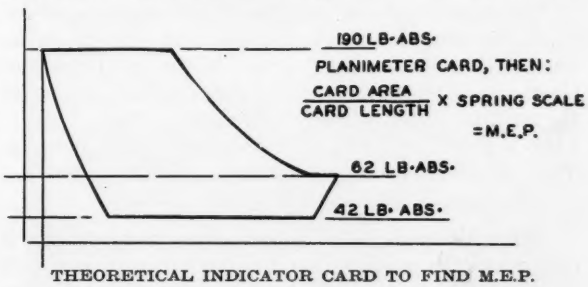
SINCE THE DEVELOPMENT of the multiple effect system of refrigeration, there has been a great deal of discussion on the proper method to obtain the power of a multiple effect machine. No method has yet been found to give satisfactory results and since it is far better to have too much power than too little available in the motor it is best to determine the horsepower required in the following manner:

By means of the planimeter or a multitude of parallel lines, determine the area of the theoretical compressor card. By the simple formula $\frac{PLAN}{33,000}$, the horsepower of one-half of the cylinder may be determined and this multiplied by two will give the approximate power required to operate the compressor. Experience has shown that the actual power required is considerably less than that determined by the indicator cards. It is, therefore, hardly necessary to add to the theoretical power for friction and other losses. The motor horsepower may be safely taken to be that indicated by the theoretical compressor card.

For the purpose of illustration, we are presenting herewith a sample set of calculations for working out a multiple effect compressor. The calculations are based on a theoretical machine and the pressures used are likewise theoretical. The value of all points given in the ammonia tables may be checked according to the Bureau of Standards Circular 142, First Edition, April 16, 1923. The Mollier diagram found in the back of these tables has been used in the calculations.

Now for a few applications of multiple effect compression and a discussion of its relative merits in ammonia and carbon dioxide systems. Considering first the ammonia system, multiple effect has a very excellent application in the ice plant which employs a forecooler. Unless there is considerable difference between the low and multiple effect suction pressures, one should not expect any marked savings in power due to the employment of such a system. Where multiple effect and low suction pressures are almost the same, double suction is perhaps simpler and less expensive. On the other hand, however, where the customer has use for 0 deg. work on the low suction and 30 deg. work on the high and where the cooling water is not too warm, multiple effect single compression may be used with marked success. Some manufacturers have designed and installed a number of two-stage multiple effect compressors and in their particular installations, these systems have been remarkably successful. An ice cream plant located in a warm climate, for instance, can use the low suction pressure for hardening, the multiple effect suction pressure for freezing, and the intermediate pressure or intercooler pressure for mix cooling and milk precooling. Several installations of this type have been made and each has performed admirably.

With carbon dioxide compression, however, multiple effect operation permits a great economy in power. In this particular system, the multiple effect pressure may be used entirely for liquid cooling and the gas boiled off in the liquid cooler be conducted directly to the multiple effect ports. Figures have shown as high as 22 to 26 per cent saving in power on shipboard where multiple effect carbon dioxide compressors have been used in place of single stage. Carbon dioxide does not lend itself at all to the two-stage compression system. Multiple effect may, therefore, be used with great advantage when calculating a plant using carbon dioxide. But perhaps the greatest advantage of the multiple effect plant over the double suction plant lies in the perfect balancing of the compressor, thus reducing the amount of WR^2 required and permitting very even and vibrationless operation.



THEORETICAL INDICATOR CARD TO FIND M.E.P.

MULTIPLE EFFECT SAMPLE CALCULATIONS

In order to present all figures used in these calculations so as to compare with the Bureau of Standards Mollier Diagram, absolute pressures (gage pressures plus 14.7 lb.) have been employed. Please remember this point in following these figures.

Assume that we have a refrigerating plant to operate at 190 lb. discharge which has loads of 152 tons at 42 lb. (14 deg. F.) suction and 42 t. at 62 lb. (32 deg. F.) suction. Two-stage compression, with the high suction pressure as the intermediate pressure, would be in a very unbalanced condition and therefore inadvisable. Accordingly, we turn to "multiple effect" as the solution to our problem.

Let us consider first the low suction load. At its conditions, 42 lb. absolute, ammonia has the following characteristics; allowing for a 10-deg. superheated condition at the compressor:

Temperature	24 deg. F. (10 deg. superheat)
Total heat	622 B.t.u. per lb.
Specific volume	6.95 cu. ft. per lb.
Entropy	1.32

Since we shall operate the high suction pressure at 62 lb. absolute and since the discharge pressure will be

*Formerly with the Vilter Manufacturing Co.

NOTE: This is the second of two articles by Mr. Hiller on this subject. The first appeared on p. 297 of the March 1 issue.

190 lb. absolute, we may as well summarize the characteristics at these points:

At 62 lb. Temperature..42 deg. F. (10 deg. superheat)
Heat of liquid.....78 B.t.u. per lb.
Total heat.....628 B.t.u. per lb.
Specific volume.....4.78 cu. ft. per lb.
Entropy 1.29
At 190 lb. Heat of liquid.....147 B.t.u. per lb.

At the low suction pressure, therefore, we should have a compressor of sufficient size to handle $\frac{152 \times 200}{(622 - 78)}$ = 55.8 lb. of NH_3 per min., or in cubic feet capacity $55.8 \times 6.95 = 388$ cu. ft. per min.

We cast about and find that an 11 by 20 duplex compressor at 112 r.p.m. will handle 486 cu. ft. per min. free gas. With volumetric efficiency corrected to 1 per cent, this compressor will handle 486×0.82 or 398 cu. ft. per min. Allowing 2.5 per cent loss of effective stroke due to ½-in. multiple effect ports, we find that this compressor will handle 398×0.975 or 387 cu. ft. per min. We shall therefore choose this machine.

The total displaced volume of this machine is 486 cu. ft. per min. It has only 97.5 per cent effective stroke due to the multiple effect ports. It also has 1 per cent clearance. The total cylinder volume to the opening of the multiple effect ports is, therefore:
$(486 \times 0.975) + (486 \times 0.01) = 478$ cu. ft. per min. This represents:

$$478 \div 6.95 = 68.8 \text{ lb. } NH_3 \text{ per min.}$$

When the multiple effect gas enters the cylinder, it compresses the whole to the multiple effect pressure, 62 lb. absolute, by adiabatic compression. Here the low suction gas has the following characteristics:

Temperature .....70 deg. F.
Total heat .....644 B.t.u. per lb.
Specific volume .....5.10 cu. ft. per lb.
Entropy 1.32

Here this gas mingles with the multiple effect suction gas entering through the multiple effect ports at conditions already named. As these ports close, we may determine the amount of gas admitted by first determining the mean conditions of the gases in the cylinder or

Temperature .....56 deg. F.
Specific volume.....4.94 cu. ft. per lb.

We already know we have 68.8 lb. NH_3 per min. in the total cylinder volume. We also know this volume is 478 cu. ft. per min. The total volume available for multiple effect gas is, therefore,

$$478 - (68.8 \times 4.94) = 138 \text{ cu. ft. per min.}$$

Allowing 5 per cent losses for wiredrawing, etc., we have

$$138 \times .95 = 131 \text{ cu. ft. per min., or}$$
$$131 \div 4.78 = 27.4 \text{ lb. per min. } NH_3$$

Since the NH_3 is expanded from 190 lb. abs. to 62 lb. abs., the refrigerating effect per pound of NH_3 is

$$628 - 147 = 481 \text{ B.t.u. per lb., or}$$

$$\frac{481 \times 27.4}{200} = 65.9 \text{ t.}$$

Some of this refrigeration, however, is taken up in liquid cooling, for we are cooling 68.8 lb. NH_3 per min. This load amounts to

$$\frac{(147 - 78) \times 68.8}{200} = 23.9 \text{ t.}$$

This allows for multiple effect refrigeration at 62 lb. absolute or 32 deg. F.

$$65.9 - 23.9 = 42.0 \text{ t.}$$

Regarding horsepower to drive the machine, we must plot a theoretical indicator card and having done so on the basis of the sample card here shown, we find that the mean effective pressure is 78.4 lb. per cu. in.

By referring to the formula

$$\frac{PLAN}{33{,}000} = \text{i.hp.}$$

we find our horsepower for *one side* of *one compressor* to be

$$\frac{83.6 \times 1.67 \times 93.15 \times 112}{33{,}000} = 44.2 \text{ i.hp.}$$

For both cylinders the power is

$$44.2 \times 4 = 178 \text{ i.hp.}$$

A 190-hp. motor would be ample for driving power under conditions assumed.

If No Planimeter Is Available

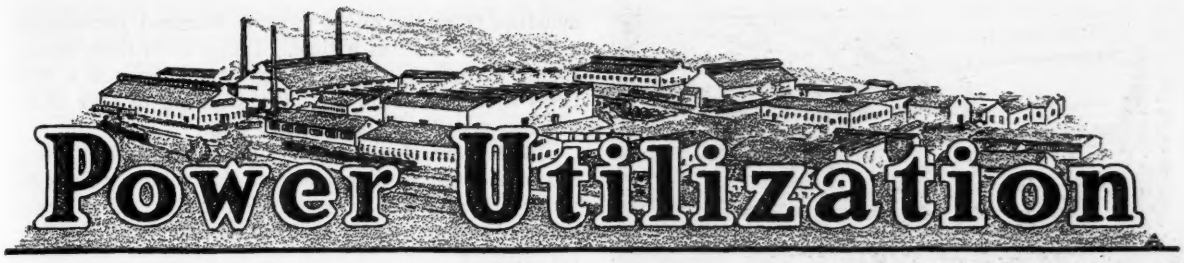
If a planimeter is not available whenever the area of an indicator card is desired, the following substitute methods may be used:

Draw a number of vertical lines, equally spaced, through the card. Measure the length of each line inside the card—that is, that part of the line which lies within the confines and boundaries of the card. Add the distances together and divide by the total number of lines through the card, thus finding the average height of the card. Multiply by the total length of the card and the product will be the approximate area of the card.

The same thing may be accomplished by drawing small squares to cover the entire card. Determine the area of each square which lies wholly within the card and then approximate the percentage of the total area of each square which lies partially within the card. Add the areas together and the result will be the approximate area of the card.

When calculating the heating surface of a boiler, considerably different results will be obtained if the inside diameter of the boiler tubes or flues is used instead of the outside diameter. In the early days, this possible difference caused much confusion but it is now the standard practice to use the surface which is exposed to the fire; that is, the inside diameter or surface for fire-tube boilers and the outside surface or diameter for water-tube boilers.

Oil storage tanks should never be cleaned without removing the cover and airing the tank for at least two days before a man is allowed to enter. Oil vapors are dispelled slowly and deaths frequently occur from this cause.



Transformer Maintenance in Industrial Plants

TESTS AND PURIFYING METHODS FOR TRANSFORMER OIL. BY DAVID R. DALZELL*

BECAUSE OF THE apparent simplicity of the transformer, it might be thought that, after once being properly installed, no further attention need be paid to it. As, however, the entire production of an industrial plant may depend upon the proper functioning of its transformers, it is best to assure continuity of service by inspecting them regularly. Fortunately, transformer maintenance centers largely around the care of the oil, the condition of which may be easily determined.

MOISTURE

After building a transformer, it is thoroughly dried to remove all traces of moisture, for moisture absorption would seriously lower the dielectric strength of the insulation. Oil in a transformer is depended upon for insulation and it too must be free from moisture. Transformers for voltages of 6000 and higher are usually shipped filled with oil, so that they may be placed in service without further drying.

When a transformer has a conservator or expansion tank, as in Fig. 1, and the main tank is completely filled with oil, there is practically no chance for moisture to enter the transformer. The breather in the conservator is the only point open to the outside air, so that any moisture entering must condense in the conservator, from which it can be drawn off through a valve provided for that purpose.

Small transformers usually have no conservators, and the air space above the oil communicates directly with the outside air through breathers or ventilators. Expansion and contraction of the oil, with changes in load, will cause the transformer to breathe, that is, exhale and inhale air. It is thus possible for moisture to be drawn into a transformer, where it condenses and falls into the oil. When the transformer exhales, all moisture may not be thrown off in the form of vapor. Some of it may remain in the oil and eventually cause trouble.

For detecting small amounts of moisture, the most reliable and satisfactory method is by measuring the dielectric strength of the oil, samples of which should be taken for this purpose from the bottom of the transformer every six months.

It is, however, possible for moisture, without mixing with the oil, to collect as free water on any horizontal surface inside the transformer. In this case, dielectric tests of the oil may show satisfactory results but traces of moisture or rust will usually appear at such points as the under side of manhole or handhole covers which, therefore, should be inspected regularly.

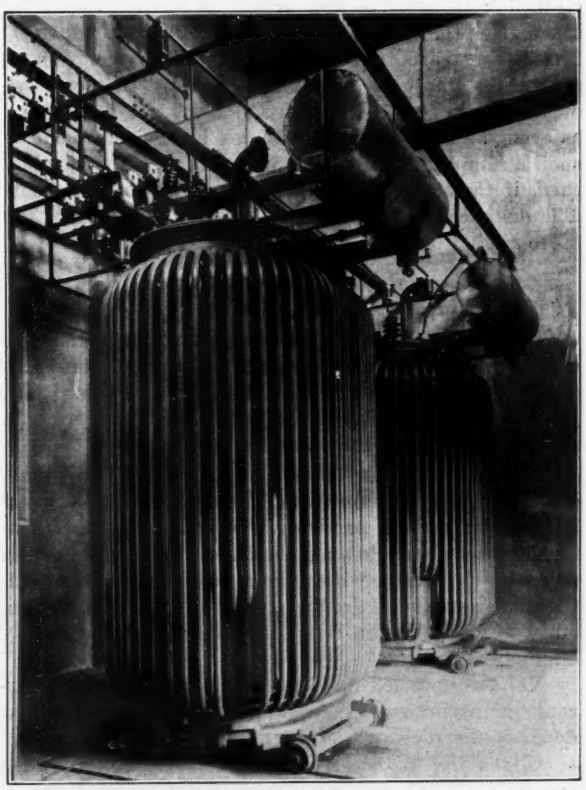


FIG. 1. LARGE TRANSFORMERS HAVE CONSERVATOR TANKS WITH VALVES TO DRAW OFF ANY COLLECTED MOISTURE

SAMPLING THE OIL

Extreme care must be taken to obtain representative samples of oil, otherwise the accuracy of the test results may be seriously affected, though the error will always be on the safe side. The following precautions are important.

Glass jars are recommended for oil sample containers so that impurities or large amounts of water in the oil

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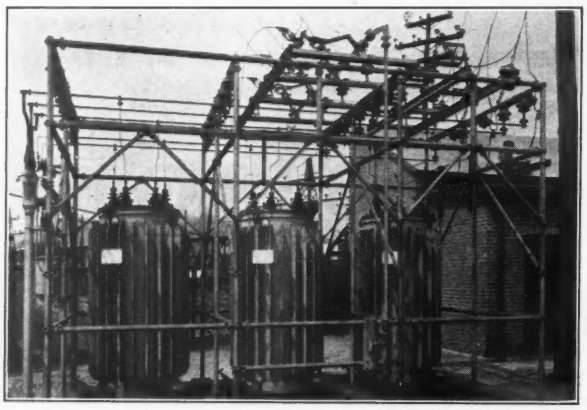


FIG. 2. TYPICAL OUTDOOR INDUSTRIAL SUBSTATION. OIL-SAMPLING VALVES ARE PROVIDED ON THE TRANSFORMER CASINGS

can be seen readily. The jars should be thoroughly cleaned with gasoline and dried. A sample should be taken from the valve at the bottom of each transformer, first taking care to flush the opening to remove any collected water or sediment and to rinse the jars two or three times with the oil. Oil must not be touched as even the moisture from a man's hand is sufficient to spoil a sample. The jars should be filled to overflowing, then, if the samples must be transported any considerable distance for test, sealed to prevent exposure of the oil to air.

Tests of Oil

Dielectric tests can be made quickly and accurately with portable high-voltage testing sets, Fig. 3, that are on the market, in which disc electrodes are mounted in a cup suitable for holding the oil. Before making tests, the electrodes and cup should be cleaned and dried in the same manner as the sampling equipment.

The test cup should be completely filled with oil, gently jarring it before each test to dislodge any air bubbles or carbon particles from the discs. If five breakdowns are made on each filling of the cup and the mean of the average breakdown voltages of three fillings taken as the dielectric strength of the sample, the effect of variations in individual fillings will be largely eliminated.

Voltage is raised until the oil breaks down and current jumps between the discs. The voltage at breakdown is the dielectric strength.

Oil having a dielectric strength of 22,000 v., when tested in a 1/10-in. gap between flat discs 1 in. in diameter, is in good condition and this value is considered as standard. When a transformer is first placed in service, the dielectric strength of the oil should be above standard. If oil in service tests less than 16,500 v., the moisture should be removed by passing the oil through a filter press, Fig. 4, purifying by centrifugal action, or by both methods in combination.

Purifying the Oil

Successful and speedy operation of a filter press is dependent upon the absolute dryness of the blotting paper used as a filler, which should, therefore, be thoroughly dried in an oven and stored under dry oil until used. Inasmuch as the paper filters out sediment and moisture from the oil, it must be changed periodically, usually one sheet at a time. Under conditions usually found in practice, one passage of oil through a filter press should raise its dielectric strength to over 28,000 v. when tested with a standard gap.

In the centrifugal purifier, the oil is forced through a bowl rotating at high speed, so that solid particles and water are removed by centrifugal action. The foreign material must, therefore, be removed from the bowl periodically.

Although it is not absolutely necessary to remove a transformer from service while the oil is being purified, it is desirable, particularly for high-voltage transformers, in order to avoid the possibility of air bubbles lodging in the windings and causing trouble.

When the dielectric strength of the oil at the bottom of the transformer is below standard, while that at the top is satisfactory, the oil should be passed from the bottom through the filter and discharged into the top. If the upper oil is poor while the lower oil is satisfactory, the oil should flow in the reverse direction to give the best results.

Purifying should be continued until the dielectric strength of oil from both top and bottom is up to standard. Twenty-four hours later, however, the oil should be tested again to determine whether the core and windings are throwing off any moisture into the oil. If this condition is found, the transformer should be thoroughly ventilated, in order to drive off the moisture in the form of vapor. Additional ventilators should be placed around the transformer cover, or the manhole cover should be raised slightly, protecting the opening from dirt and the weather.

Drying a Transformer

If after purification of the oil and continued ventilation of the transformer, traces of moisture are still found, it is evident that the core and windings need to be dried. Small low-voltage transformers (below about 150 kv-a. and below 6000 v.) can best be dried by heating in an oven at a temperature not exceeding 85 deg. C. (185 deg. F.) The exact time required depends on the condition of the transformer, but the process can be hastened by placing a pan of calcium chloride in the oven.

The most effective method of drying a larger transformer is in its own tank immersed in oil, by means of

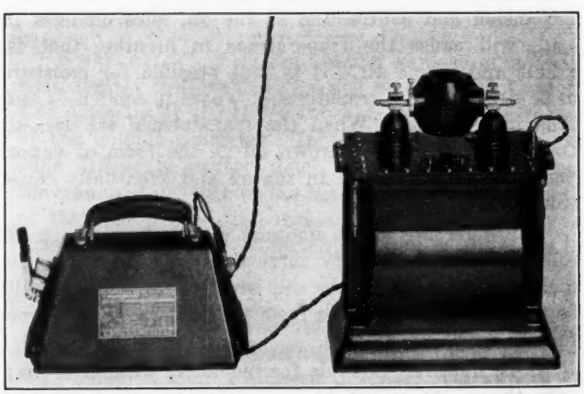


FIG. 3. PORTABLE TRANSFORMER MAKES TESTING OF OIL EASY. THE HANDLE CASE COVERS THE OIL CUP WHEN CARRYING

heat generated internally, short-circuiting either of the windings and passing some fraction of full load current through the other. The voltage required to obtain this current will be the same fraction of the impedance voltage; the value of that voltage, expressed in per cent of the rated voltage, will usually be found on the nameplate.

If the per cent impedance voltage is unknown, it may be obtained by short-circuiting either winding of the transformer (usually the low-voltage winding) and applying to the other winding at rated frequency such voltage as will cause rated current to flow through it. The rated current of either winding is equal to the rated kilovolt-amperes, multiplied by 1000 and divided by the rated voltage of the same winding. Applied voltage to give rated current will be the impedance voltage and, when this is divided by the rated voltage of the winding to which it is applied and multiplied by 100, the result is the per cent impedance voltage of the transformer.

Success of the short-circuit method of drying depends upon the maintenance of the top oil at a temperature of from 80 to 85 deg. C. (176 to 185 deg. F.). The exact amount of load current that can be held with these high oil temperatures, without possibility of danger to the windings, will depend upon the design of the transformer. For this reason, the manufacturer's instructions should be studied carefully before the drying run is started. To attain high oil temperature with partial load, it will be necessary to blanket the outer surface of the tank with heavy paper or felt, or to lower the oil below the upper end of tubes or radiators. With water-cooled transformers, the oil temperature can be controlled by the amount of water flow.

Moisture will rise from the oil in the form of vapor and escape from the transformer, if the cover or manhole cover is raised slightly to allow free circulation of air underneath. Removal of moisture can be hastened by filtering the oil, taking it from the top and returning it to the bottom of the tank. This will tend to cool the oil and the load current will usually have to be increased or else more blanketing placed around the tank.

Dielectric tests of the oil should be relied upon to determine when the transformer is dry. Oil from both the top and bottom should test at more than 22,000 v. for seven consecutive samples taken 4 hr. apart, with the oil maintained at maximum temperature and without filtering.

If necessary to add oil after the drying run, it should be pumped into the top rather than the bottom of the transformer, so that air bubbles will not enter the windings.

Sludging of the Oil

When heated, oil slowly oxidizes and, ultimately, a deposit known as sludge may be formed. This will tend to block the oil ducts, thicken the oil and increase the temperature of the windings. If not checked, the insulation may be weakened and the transformer may fail.

Properly designed, the conservator or expansion tank keeps air away from the hot oil, thereby making the formation of sludge practically impossible. When taking periodic samples, if the oil is found to be very much darkened or if it contains sludge, that is an indication of overheating and the cause should be determined. Transformer core and windings should be removed from the tank for inspection and, if they are thickly covered with sludge, it should be removed by washing with clean oil under pressure, obtained with a filter press pump.

Filtering will remove sludge from oil but new deposits will be formed much more quickly than with new oil, hence, in aggravated cases, new oil should be placed in the transformer.

Permissible Load and Temperature Limits

Most transformers are designed to operate at their kilovolt-ampere rating continuously, without their temperature rise exceeding 55 deg. C. (100 deg. F.). This refers to the rise in temperature of the windings above an arbitrary standard temperature of the cooling medium, which is 40 deg. C. (104 deg. F.) air temperature for a self-cooled transformer and 25 deg. C. (77 deg. F.) ingoing water temperature for a water-cooled transformer. Experience of many years has shown that these operating temperatures are the highest that it is desirable to maintain without danger of early deterioration and failure of transformer insulation.

For this reason, for each degree that the temperature of the cooling air is higher than 40 deg. C., or that of the cooling water is higher than 25 deg. C., the load on the transformer should be decreased by 2 per cent.

Heavy overload may be placed on a transformer for several minutes and a slight overload for a longer time. If the temperature of the cooling medium is low, the transformer can be overloaded continuously; for example, the load on a transformer can be increased by 1 per cent for each degree Centigrade or 2 deg. F. that the cooling air is lower than 30 deg. C. (86 deg. F.), or the cooling water is lower than 25 deg. C. (77 deg. F.).

As the temperature of a transformer winding varies with the load much more rapidly than that of the oil, it is unwise to control the loading by the temperature of the top oil alone, although thermometers are usually

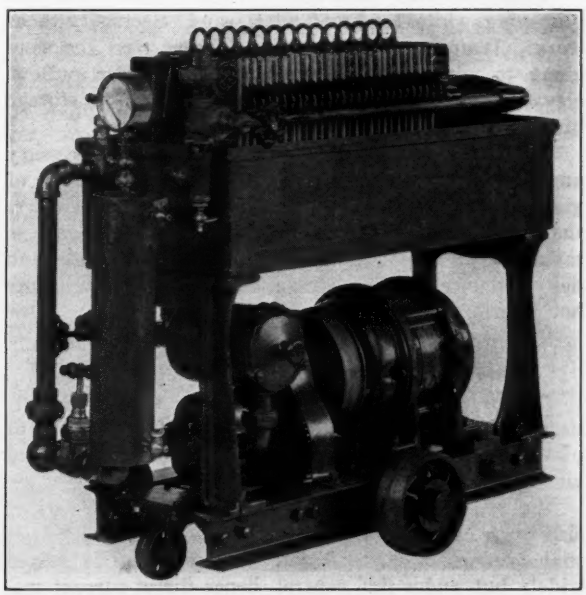


FIG. 4. DRYER AND FILTER PRESS FOR PURIFYING OIL

provided for making a rough check. The oil temperature of a self-cooled transformer with a conservator should never exceed 80 deg. C. (176 deg. F.), or 75 deg. C. (117 deg. F.) without a conservator. For a water-cooled transformer, these values are 65 deg. C. (149 deg. F.) and 60 deg. C. (140 deg. F.), with and without a conservator respectively.

Another simple method of checking the condition of the transformer is to note the difference between the temperature of the top oil and that of the cooling medium. This temperature difference should never, under the same load conditions, be more than 5 deg. C. (9 deg. F.) greater than when the transformer was first placed in operation.

Care of Tank and Water Coils

If a transformer is located so that dust or other foreign material can fall on it, it should be removed from service at regular intervals and the porcelain bushings wiped clean so that they will not arc over.

Paint on a transformer should be kept in good condition in order to prevent rusting. A good outdoor paint of any color may be used, although a metallic-base paint such as aluminum should not be used in a dark place, because the temperature of the transformer oil will be considerably increased.

Cooling coils of water-cooled transformers occasionally become clogged with scale or rust to such an extent that the required amount of water will not flow through and the transformer will overheat. In this case, the transformer should be removed from service and the cooling coil filled with a solution consisting of equal parts of commercially pure concentrated hydrochloric acid and water. After about an hour, this should be drawn off and the cooling coil flushed out with clean water. This process may have to be repeated, using a new solution, several times until the coil is clean. One or both ends of the cooling coil should be left open to vent the gases formed by chemical action.

When a water-cooled transformer must stand out-of-doors idle for any length of time, exposed to freezing temperatures, the cooling coil should be emptied of water, should then be dried by blowing warm air through it and filled with transformer oil to prevent condensation of moisture. These precautions will prevent a burst cooling coil.

Electricity and Bottles

Tons of Sand, Lots of Hot Air Plus Thousands of Kilowatt-Hours = Millions of Bottles. By L. E. Beneze*

BOTTLES, in a varied succession of forms, sizes and uses are with us in daily life from the cradle to the end. In their manufacture and that of other glass containers, electricity is all important, again proving itself an indispensable servant of industry. Let us follow some of its uses from raw material to finished product.

Electric Transport

From the time that motor-driven shovels bite into glistening white banks of silica sand, electricity is at work. Trains, grinders, dryers, screens pass the sand along to mixing plants where cable-drag car pullers, elevators, more shovels and buckets deliver it to storage bins.

Gathering cars collect from the bins the necessary amounts of various materials to form a "batch" of glass of the desired quality and deliver to big mixers that handle 4 t. at a time. Thence the batch goes to tanks, drawn by electric locomotives to the furnaces and delivered in an endless stream for melting to the white hot interiors by screw conveyors.

Hot Bottles

To measure and control temperatures in these furnaces, which rise to 2700 deg. F., rare metal couples of platinum-rhodium are used, delicately gaging fuel and air supply and regulating draft.

Melted, the batch flows to bottle machines of various sizes with capacities of 5 to 100 t. each, making bottles to hold from 1 oz. to 5 gal. Speeds must be varied widely but under fine control, hence direct-current motors are used for drive and dynamic braking so that quick stops can be made.

Molten glass is hot, for both machines and the men operating them. Ventilation and cooling are needed and to give these cooling fans of 15,000 cu. ft. per min. are provided, of course motor driven. Even so, the product, now finished, is at a temperature of 900 to 950 deg. F. and must be tempered or annealed so that unequal cooling strains will not snap the brittle material. As the containers filled with bottles come from the machines, they are taken to annealing ovens or lehrs where they are cooled gradually, the temperature gradient of the 70-ft. ovens from 1100 deg. to room temperature being controlled electrically to within 10 deg. plus or minus at all points.

Finally, cooled and ready for inspection and packing, the bottles emerge from the lehrs, transportation during both processes and afterward being by means of conveyors, motor-driven.

Meanwhile lumber, corrugated board and containers have been brought by conveyors to the inspection and packing departments so that bottles may be on their way to babies, drug stores, doctors, pop factories and chemical works without delay. Packed and labeled, again conveyors come into play to speed the ever useful bottle to its work.

Motors everywhere, 1200 or more in the plant, ranging from 1/75 hp. for instrument drives to 650 hp. for big air compressors. Lights, of course, 7000 of all kinds; a total monthly consumption of over 1,250,000 kw-hr.

In the Alton plant of the Owens-Illinois Glass Co., it has been found good economy to purchase most of the

*Chief Engineer, Owens-Illinois Glass Co., Alton, Ill.

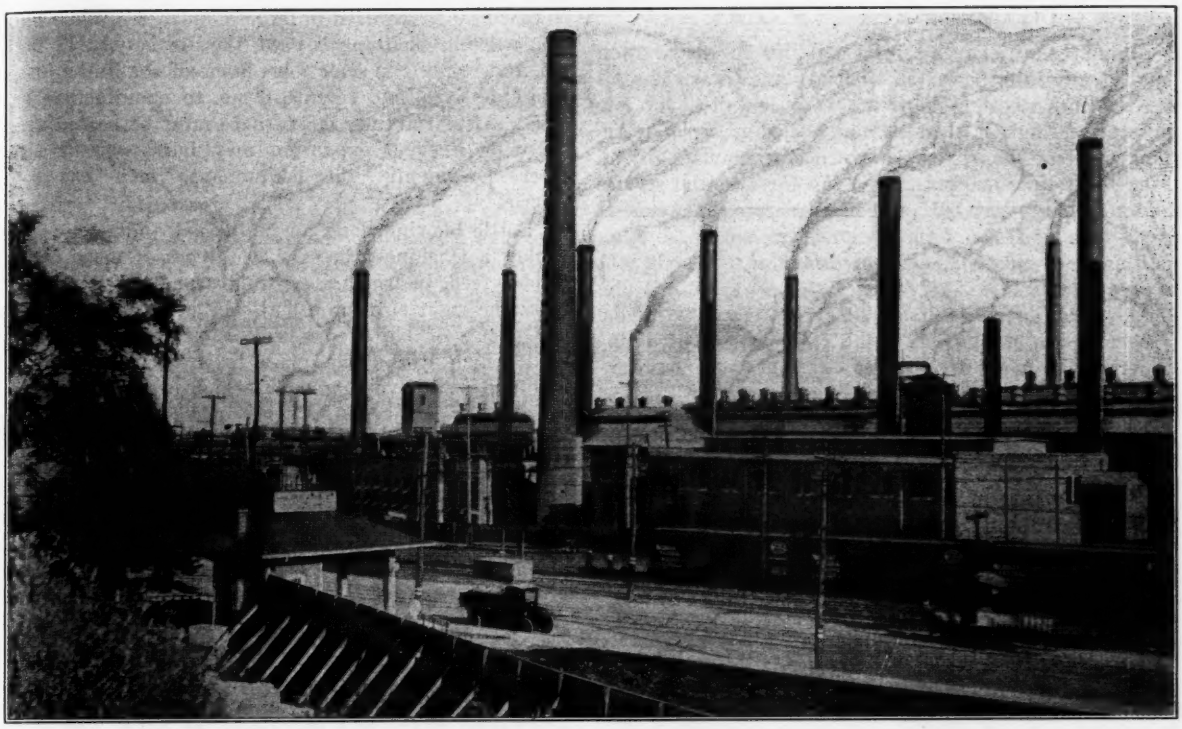


FIG. 1. THIS PLANT AT ALTON, ILL., IS ALL OCCUPIED IN MAKING BOTTLES, CONTAINERS AND BOXES

power, 5000 kw. of capacity, and generate the rest, 1200-kw. capacity from steam used for process work; this for a plant whose glass output is 400 t. in 24 hr.

For the purchase power, two parallel lines for current at 33,000 v., 60 cycles, 3-phase are run by the public service company to feed two banks of three 883-kw. transformers each, stepping down to 460 v. From the transformers, current goes through eight 1,000,000 circular-mil cables in underground ducts with concrete envelope to the power-house switchboard. Two 4000-amp. circuit breakers are used ahead of the four 4 by ½-in. copper buses from which double throw switches connect load either to the purchased power buses or the generated power. Purchased power and generated power are not used in parallel or on the same distribution circuit.

Distribution to load centers calls for 13 circuits as follows:

Six	of	700,000	circular mil	cable	for	600	amp.	ea.
Three	"	1,000,000	"	"	"	1000	"	"
Three	"	400,000	"	"	"	300	"	"
One No. 1 wire for 100 amp.								

All circuits carry 460 v. except one which is nearly a mile long where the voltage is stepped up to 2200 v. Cables leave the power house in underground fiber ducts with concrete envelopes.

Motors are for 440 v. except some special applications for 220 v. and about 250 kw. of direct-current motors where wide speed range and close regulation are essential. For the 220-v. motor supply, and heating load, three banks of 333 kw. each and a bank of 135-kw. transformers are installed at load centers stepping down from 460 to 230 v. while for lighting, four banks of three 25-kw. transformers each, reduce voltage to 115 v.

Direct current is supplied by motor-generator sets, motors being synchronous and the sets placed as near the point of use of the direct current as possible. The sets, which are operated only as needed, are three of 15 kw. each, and one each of 100, 70, 40 and 25 kw.

For the most part, motors are three-phase squirrel cage but to keep power factor up nearly to unity, two 650-hp., four 125-hp. and one each of 300 and 225-hp. synchronous motors are used, excitation being regulated to control the power factor.

Furnace cooling and process work demand a supply of 1,000,000 gal. of water daily which is handled by motor-driven pumps. Also, at certain seasons, the river level is above the sewer outlet so that some 15,000 g.p.m. of sewage and surface water must be pumped to the river, involving a not insignificant pumping station.

FIG. 2. BLOWERS AND CONTROL REPLACE THE LUNG POWER OF THE GLASSWORKER

Distribution Must Be Flexible

Plant conditions call for flexibility in distribution but for unfailing power on what are known as essential service lines where a shutdown would entail heavy loss in product and in cleaning out cooled material. Arrangement of the system is shown diagrammatically in Fig. 3, the lines marked E.S. being for essential service and normally operated on home-generated power. It

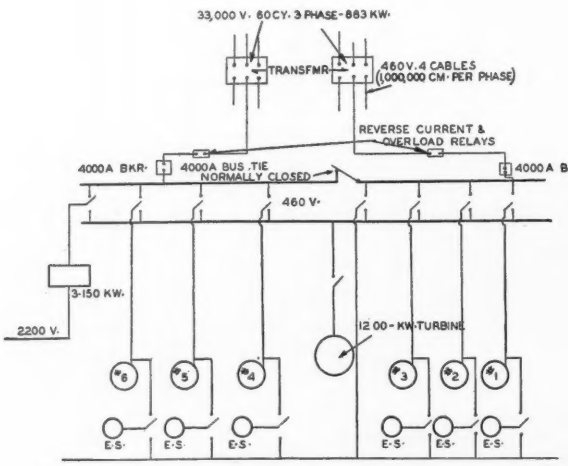


FIG. 3. PURCHASED OR GENERATED POWER MAY BE USED ON ANY SERVICE

will be seen that these services have four possible chances to get power, through the E.S. bus from either the 1200-kw. turbine or either of the 33,000-v. lines or direct from the 460-v. purchased-power bus.

Except for a few lines which are carried above buildings, all wiring is in conduit, of which some 90,000 ft. is used.

A glance at some of the problems and methods will give a better insight into power and heat uses for bottles. In the melting furnace, a temperature of 2700 deg. must be held, heat being applied above the glass rather than below. Some 250 t. are melted in a charge, so that heat is required in large quantities. While high-grade fire brick lining is used, the life is only 12 to 15 mo. and relining is some job. Some of the lining blocks weigh 1800 lb. and require 6 mo. to manufacture and cure. After relining, the furnace must be heated gradually or unequal expansion may burst one of these blocks. Evidently the maintenance man has some worries.

Bottle blowing, long an individual and manual job, is now a machine process. Two types of machine, the "gob" feed, in which a central furnace feeds a gob of glass the right size for a bottle by gravity to a revolving group of blowers in succession, and the vacuum feed which draws the glass to a group of blowers mounted on a revolving table, which present themselves serially for a charge. After a charge is in the measuring blank, a metal tip descends to form the neck or finish, the glass, now white hot, plastic but not molten is relieved from the blank, surrounded by the finishing mold and blown out by air admitted through the neck tip. This is all done in less time than it takes to read about it, the rate being a bottle a second for small ware, a gallon bottle in 4 sec. and a big carboy in one minute.

Obviously, machinery to do such work requires the greatest accuracy in control of speed, action and temperatures.

Handling of materials and packages, manufacture of corrugated board and containers, of boxes and crates are applications of power similar to those in many in-

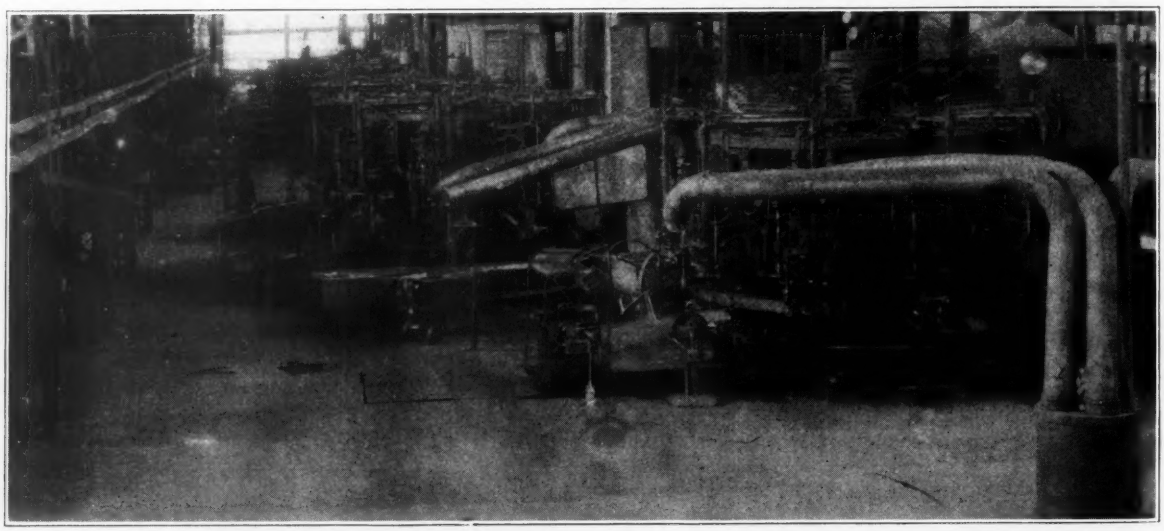


FIG. 4. BOTTLE BLOWING MACHINES REQUIRE POWER, HEAT AND COOLING BLASTS

dustries but adapted in details to the needs of the bottle plant.

Into the making of the bottle which the boy kicks down the alley has gone an almost unlimited amount of care and thought but the chief factor in producing it at low cost has been the adaptation of power-driven machinery to its production.

Optical pyrometers used for measuring high temperatures are based on the principle that the intensity of light given off by incandescent bodies varies in a definite relation with the temperature.

Compressed Air in Industry

By H. L. Kauffman

THAT COMPRESSED air is used for a great variety of purposes is commonly known but few appreciate just how great are the possibilities for development and how its scope is being widened almost daily.

One of the most important uses of compressed air is in the operation of pneumatic tools such as hammers, drills, riveters, as used in engineering works, boiler shops, foundries, forge shops, shipyards, docks and in bridge building. Rock drills used in mines and quarries are operated by air under pressure, as is also underground machinery used in collieries. The sinking of shafts and the driving of tunnels on the scale now pursued would be economically impossible were it not for the air-driven rock drill which, in mines and tunnels, reduces costs to a minimum.

Over 5000 air-driven rock drills and other pneumatic equipment are in daily use in New York City in excavating for foundations, in building subways, in drilling and chipping work on the streets, and in doing other kindred work.

Spraying

Of particular interest at present is the variety of uses of, and materials being applied by, the spray gun. Instead of putting color in the mix or painting the material after it has hardened, cement is now being colored by dampening it with a stream of water, then blowing thereon, with a suitable spray gun, a dry, cement-like powder of any desired color. It is said that the powder combines with the water and adheres to the rough surface, forming a permanent coating that is also waterproof and it is also understood that metal, wood, stone and the like can be similarly treated.

Roofs are now heat insulated—as a matter of fact, entire buildings are being sound-proofed and heat insulated—by a material now available and applied with a special spray gun. Bits of waste paper and cloth, the sizes of confetti, are the base of the material, which is mixed with a solution of silicate of soda or water glass, a syrupy fluid that makes an excellent binder. The outfit, Fig. 1, used to shoot this composition into place consists of a specially designed spray gun and a gasoline motor that drives a dynamo to operate an air pump that feeds the loose flakes to the gun and a small air compressor which provides the air that adds the liquid binder and sprays the resulting mixtures against the surfaces to be protected. The light fluffy material is forced through a jointed pipe and a length of flexible hose to the gun, where it is mixed with the silicate of soda entering at that point by way of two feed lines. These feed lines terminate in two nozzles, one on each side of the gun, through which the strongly adhesive composition is forcibly discharged in the form of a spray. Once dry, coatings of this description are hard and permanent. Because of the thousands of air cells contained in the fibrous mass, they are said to possess excellent insulating and sound-proofing properties.

Electric ducts must be clean and well lubricated before they can receive their cables. Compressed air now is aiding in cleaning and lubricating such ducts. In about 10 min. a high-pressure soapstone gun will do this work on conduits having an average length of 400 ft., forcing through about 15 lb. of material for each 100 ft. of duct. The propulsive power of compressed air is also being used to shoot a home-made "bullet" carrying a trailer wire through ducts preliminary to pulling the cables through.

FIG. 1. APPLYING HEAT INSULATION TO BUILDINGS

Spraying of atomized metal upon other metals and materials is one of the most recent uses of the compressed-air-operated spray gun. Concrete can be thus coated with molten tin, zinc or lead, while such metals as aluminum can be applied in the form of a spray to other metals.

Conveying

Most jobs of conveying are performed by blowers or similar low-pressure exhaust systems, hence not properly within the scope of this article, which has to do with the uses of high-pressure air.

In some instances, however, only high-pressure air will do the work. For example, in an oil refinery, to elevate sulphuric acid from ground level to a height of possibly 50 or 60 ft. into an agitator, when treating lubricating and other oils compressed air is required. In oil refineries and other plants, compressed air is necessary to empty pipe lines containing oil, water and other liquids. Air under pressure has also been used in helping to convey mixed concrete from the point of mixing to the place where used. Pulp for paper making and similar materials have been conveyed from place to place by the aid of high-pressure air. Air-operated pumps are widely used in handling cement and other finely ground materials through pipes, as shown in Fig. 2, an Ingersoll-Rand system.

Pneumatic tools and air-operated hydraulic presses, hammers, and the like, have been responsible to a great degree for the marked progress in all lines of industry the past decade.

Hammers operated by compressed air make possible the huge oil-well drills that permit us to get petroleum from wells 8000 ft. deep. Enormous cylinder molds are reamed with air-operated reamers. Pneumatic grinders are used to surface castings for large dies. Pneumatic drills are employed in all types of construction work.

How Power Companies Are Using Compressed Air

Columbia Power Co., Cincinnati, Ohio, is one of at least several companies using compressed air instead of steam for blowing soot.

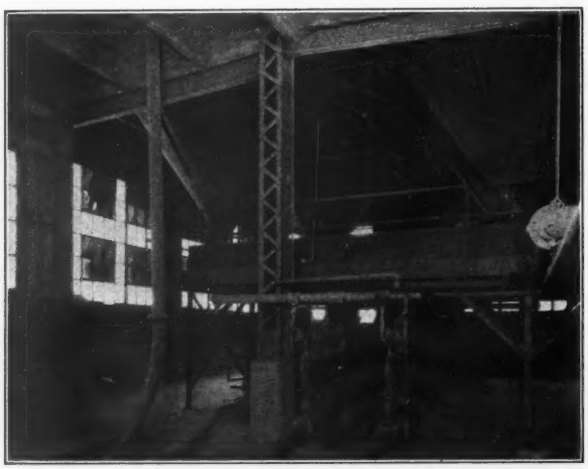


FIG. 2. FULLER-KINYON PUMPS FOR HANDLING CEMENT PLANT MATERIAL

Not being satisfied with the speed of a boiler-tube cleaner, operating with water under a pressure of from 100 to 125 lb., the idea was conceived by a plant engineer of utilizing compressed air in combination with the water. The results were entirely satisfactory, the cleaner doing its work in less time than formerly, while the water keeps the tool cool and washes the dirt out of the tubes.

On the Tippecanoe River in Indiana, at the Norway plant of the Indiana Hydro-Electric Power Co., a compressed-air system for preventing ice formation along spillway flashboards has been in successful operation for several winters. An open area of water is maintained by jets of compressed air, thus preventing ice pressure against the flashboards. Compressed air is used by the City of Seattle at its hydroelectric plants to safeguard the stations from the hampering effects of ice during the winter and from fine trash at all times. The accompanying illustration from Compressed Air Magazine shows the arrangement of the installation at the Cedar Falls unit, which has kept intakes clear even when ice formed 10 in. thick.

At the Mitchell Dam of the Alabama Power Co., intake screens are kept clear of trash by compressed air, each submerged screen being provided at the intake gate with an air installation at the bottom. This is an 8-ft. length of 1¼-in. extra strong pipe drilled with 22 ⅛-in. holes on 4⅜-in centers, arranged in a wavy line. The air rises along and in front of the racks, carrying trash with it.

Miscellaneous Uses of Compressed Air in Industry

Air-motor driven saws make it possible to cut materials under water. Air-operated hoists, jacks and lift tables are used in innumerable manufacturing plants, foundries and shops. Air-operated surfacing machines give us the highly polished marbles used in building construction. Air-driven locomotives are employed in ammunition depots for transporting high explosives within the confines of the depots.

Air-operated doors are now in use, the compressed air passing through an electrically controlled valve that can be operated by any desired number of switches, thus making it possible to control a door from convenient stations inside and outside the building. This can be done at any desired rate of speed through the medium of a pressure-regulating valve, which admits just the right amount of air into the cylinder attached to the door itself.

Air under pressure is used in the operation of almost all filters where solids are being separated from

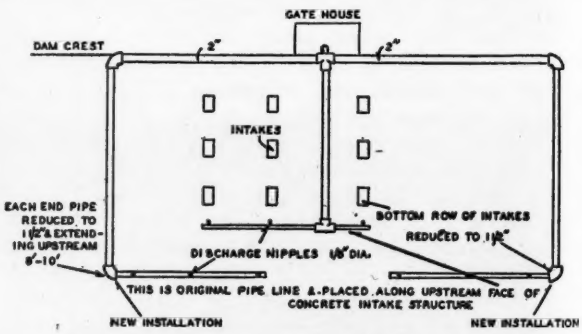

GATE HOUSE
DAM CREST
2"
2"
INTAKES
EACH END PIPE REDUCED TO 1½" & EXTENDING UPSTREAM 8'-10'
BOTTOM ROW OF INTAKES REDUCED TO 1½"
DISCHARGE NIPPLES 1¼" DIA.
THIS IS ORIGINAL PIPE LINE & PLACED ALONG UPSTREAM FACE OF CONCRETE INTAKE STRUCTURE
NEW INSTALLATION
NEW INSTALLATION

FIG. 3. AIR SYSTEM AT CEDAR FALLS DAM FOR KEEPING INTAKES CLEAR OF ICE

liquids. Compressed air is forced into oil-bearing sands to increase oil production.

Sand blasting is used to the greatest extent in foundries, to clean castings of iron, steel, brass, bronze, aluminum and other metals. By so removing sand and scale before the work is machined, the life of machine-shop tools is much prolonged. Sand blasting effect can be modified at will by varying the pressure and the cross section of the air current, as well as the volume and the character of the sand grains. For rough work, metallic fragments are used in place of sand. Sand blasting is used for the removal of paint, grease and scale from large metallic structures such as bridges and oil tanks, before painting also for scouring brick or stone buildings to restore their original appearance.

High-pressure lubricating systems are possible only because air under pressure is available to force the grease through the specially designed fittings to the parts to be lubricated.

Plastic refractory materials are now used in patching and repairing furnace walls and arches as well as in new construction, being blown into place by refractory guns of special design.

Locating Defective Pumps

By C. W. Stevens

IT WAS during a very hot spell last summer when our load on our water pumps began to go up by leaps and bounds, and we added pumps to the line until we had all four centrifugal pumps going with only two old duplex plunger pumps available as spares. This spare capacity was very much a dubious asset in case of a breakdown.

We knew that some of the pumps were not delivering the goods, as the pump capacity on the line was about double the volume shown on our Venturi meters, yet we were just holding our own, barely keeping the standpipe full. We didn't dare to start tearing down the pumps one at a time to correct worn impellers, etc., for fear that we'd get our best pump out of service.

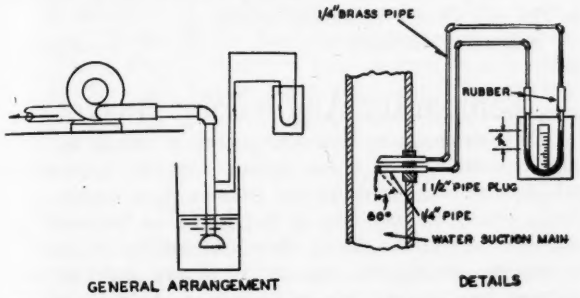


FIG. 1. ARRANGEMENT OF PUMP AND PITOT TUBES
FIG. 2. DETAILS OF PITOT TUBES AND CONNECTIONS

In order to determine which pumps were delivering water and which ones to take off the line and repair, we decided to make up a set of home-made Pitot tubes for insertion into the water flow of each pump. Since the delivery pressure was 120 feet, and we had to use rubber tubing with glass U-tubes for the differential, we utilized the suction lines of the pumps.

The accompanying sketch shows the general arrangement of our "instruments." A 1½-in. pipe plug was drilled and tapped from the inside surface for two ¼-in. pipes to go all way through. A corresponding 1½-in. tap was placed in the suction line of each pump at sufficient distance from the pump to give as nearly streamline a flow as possible, that is, proximity to bends and fittings was avoided. Two ¼-in. brass tubes were cut and screwed through the plugs so that the inside ends, which were cut at 30-deg. angles to the axis of the brass tubes, were in the center of the water flow, at the axis of the water line. The extending pieces of the brass tubes were connected to a glass U-tube filled with mercury by means of more brass pipe and short rubber connections. Of course the angled faces of the inside Pitot tubes were faced up and downstream properly. All four pumps were treated exactly alike in every respect, without partiality.

The results were surprising. The readings showed us at once, which pump to tear down first, as it had a very small differential. The readings simultaneously taken showed results something like this:

Pump No.	1	2	3	4
Differential, in., mercury.	4	15	9	16
Square root	2	3.86	3	4
Per cent of total delivery.	15.6	30.0	23.3	31.1

Immediately, we knew that Pump No. 1 was delivering but 15 per cent of our capacity and we prepared to remove it from the line first.

Of course, we could not use the Pitot tubes as meters for an accurate record of the water flowing through the lines. But we could easily determine this fairly accurately by multiplying the above percentage by the total water recorded by our discharge Venturi meter. As the Pitot tubes were identical installations in identical lines, the differential pressures are produced by relative flows. This was all we wanted. This arrangement worked so satisfactorily that later it was redesigned as a permanent installation.

We were soon able to carry the full load on two and occasionally three pumps, maintained in good condition. We always had a spare centrifugal, as we knew when it needed overhauling.

Scraper to Clean Valve Discs

This simple scraper is easy to make and will be of considerable value as an emergency tool. Two pieces of tempered steel plate ½ in. thick, 4 in. or more high, and 10 in. long have the top edge of each piece ground to a sharp edge as shown, are bent to a right angle and fastened to a plank, the distance between being the diameter of the valve stem.

When a pump is handling certain liquids or a hard lime water, the flat side of brass valves often becomes

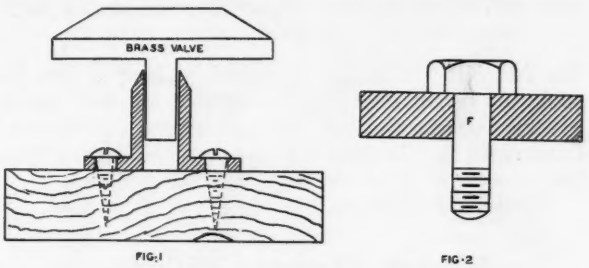


FIG. 1. DETAILS OF SCRAPER FOR VALVE DISCS
FIG. 2. COMPOSITION DISC CAN BE REFACED

coated with a hard scale, which is difficult to remove from the valve face. Files or other unsuitable tools are resorted to, sometimes resulting in a permanently scored valve.

The sharp edges extend all the way across the valve, overlapping the diameter at each side, so that, by pressing down on the valve and at the same time turning it, all scale will be removed leaving the valve face clean and uninjured.

A slightly scored hard rubber composition pump disc valve can be refaced with this tool, by inserting any bolt as F, having the same diameter as the valve stem to make a neat fit in the valve stem hole in the disc. This bolt serves to hold the valve disc central, while it is revolved against the scraper edges, which are otherwise liable to leave ridges across the face of the disc.

The tool described is for valves up to 9½ in. diameter. Thinner, shorter and narrower metal can be used for smaller valves, although valves all the way up from 2 in. to 9½ in. diam. can be scraped with the thick wide metal scrapers. In any case, the metal

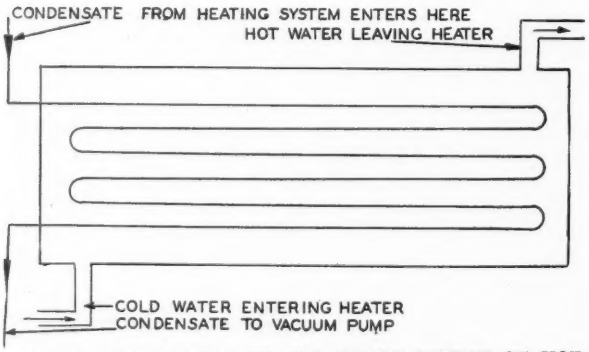
should be heavy enough so that there will be little or no spring while turning the valves and the edges should be kept sharpened, free of notches, even and level.

Toronto, Can. JAMES E. NOBLE.

Water Heated by Condensate

THIS HEATER does away with the use of injection water in a heating system where vacuum pumps are used to handle condensate. It is simple yet effective, as it saves both heat and water.

The shell can be made of pipe 20 to 30 in. diameter, large enough to carry a sufficient hot water supply and the coil of any size and amount of pipe, but it pays to use plenty of pipe surface and high velocity through the pipe, since long fast travel assists in heat transfer.


CONDENSATE FROM HEATING SYSTEM ENTERS HERE
HOT WATER LEAVING HEATER
COLD WATER ENTERING HEATER
CONDENSATE TO VACUUM PUMP

COIL AND SHELL HEATER FOR PLANT SUPPLY OF HOT WATER

The fuel bill will be decreased and, so long as care is taken to prevent scale forming on the coil, this heater will give satisfaction for years, at no cost for repairs. Condensate may be from a prime mover, a heating system, process work, or the drip from steam mains.

Kansas City, Kansas. J. F. STALEY.

Electric Elevator Failures

UNSATISFACTORY operation of an electric elevator led to an examination and test which resulted in the discovery of earth faults in the cable connecting the main double-pole switch with the controller and also in the control cable.

These cables had been drawn into conduit which was of very light gage and which had been bedded also in plaster made from sea sand, causing the plaster to become corrosive, as moisture was present. The corrosion had been severe enough to corrode the conduit completely, permitting moisture to enter and attack the cable, which in turn caused the insulation faults to develop.

Had the conduit been of heavier gage, it might have withstood the attack. Sea sand should never be employed to make plaster in which conduit is to be embedded. In this instance it was necessary to renew both the conduit and the cable and make necessary repairs to the brake coil.

In another instance, a grinding noise was heard in the worm gear base of a passenger elevator. This was driven by an 8-hp. motor which was direct connected to a single threaded steel worm. This worm meshed with a worm wheel, built up with a cast-iron center and a phosphor-bronze rim, which connected to the hoisting gear.

On examination, the teeth of the worm wheel were found to be almost worn away. All the gears were badly damaged and the journals scored. The balls in the end thrust bearing were found to be broken and partly ground up. The trouble evidently started with wear in the ball thrust bearing, which caused the end play to become excessive and permitted hammering which finally resulted in breakage of the balls.

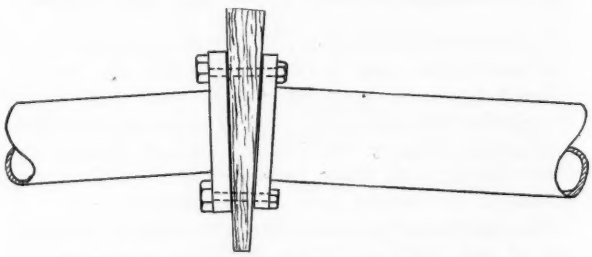
Breakage of one ball soon led to breakage of the remainder. Particles of the broken balls would easily work through to the gear teeth and cause them to wear excessively. At the last inspection, excessive end play in the thrust bearing had been noticed but this play was not taken up at the time.

A complete replacing of the gears was necessary. Faults of this kind are often indicated by the movement of the car when a passenger enters.

Brighton, England. W. E. WARNER.

Temporary Angle Joint Gasket

ON ONE occasion, it was necessary to install a pump and run an 8-in. pipe line around several obstructions where time was precious and fittings were scarce. On coming to the last joint, it was found to be decidedly out of line and the sketch shows the method of making a wooden "Dutchman" which will fit any angle between flanges by varying the number and position of the



WOOD GASKETS CONSTRUCTED OF SHINGLES

shingles used. Measurements were taken at the top and bottom openings and wide shingles selected and stacked to give the required dimensions. These were then tacked in place, a hole sawed out with a scroll saw the size of the internal diameter of the pipe and bolt holes drilled.

It is well to back up the shingles with a board when drilling so that the wood will not split when the drill breaks through. This filler is not recommended for high-pressure lines and if time and equipment are available it is, of course, much better to make a welded joint.

Lincoln, N. H. A. P. NUTTER.

FLUIDS MAY BE either liquids or gases and a general study of the laws and principles of liquids is known as hydraulics, although this usually includes the two divisions of the subject—hydrostatics, dealing with liquids at rest and hydrodynamics, dealing with liquids in motion.

SAMUEL YELLIN, Philadelphia's master craftsman in wrought iron, is the owner of a small wrought iron figure which was found in Italy and which was fashioned more than 3500 yr. ago.

Horizontal Boiler Baffles

IN REGARD to a letter that appeared in the Feb. 1 issue of Power Plant Engineering on page 195, the figure used was apparently a reproduction of a drawing arranged by the writer for a copyrighted article that appeared in one of the papers presented before the Fuel Session of the American Society of Mechanical Engineers and, if so, was used without permission. The Enco Cross Baffle shown in the drawing was designed by the writer and installed in the plant of the Michigan Carton Co. at Battle Creek, Michigan, by the Engineer Co., sole licensee under the writer's patents, after conferences with both the boiler and stoker manufacturers. It has been a successful installation.

Since the appearance of that article, the writer has secured from W. E. Sooy, the secretary and mechanical engineer of the Michigan Carbon Co., a letter bearing on the operation of this installation, as follows:

"In answer to your question regarding soot and ash accumulation, this caused us a little trouble when the installation was first completed. By changing the position of our soot blowers, this was very easily eliminated, and we do not experience any trouble since making the change.

"We are very well satisfied with the results, from both an operating standpoint and efficiency that we have obtained from this installation."

The writer has also been advised by the Diamond

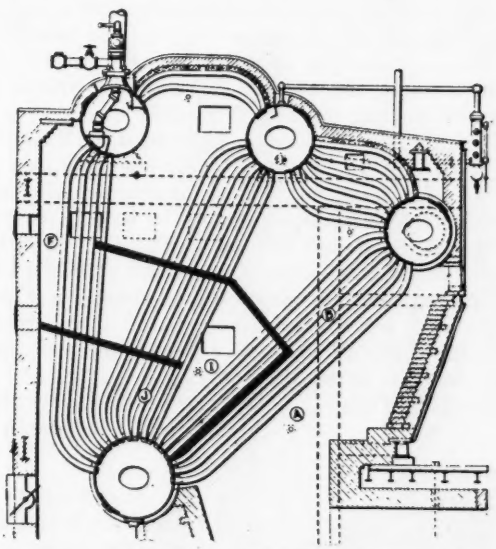


FIG. 1. BAFFLE AT MICHIGAN CARTON CO.

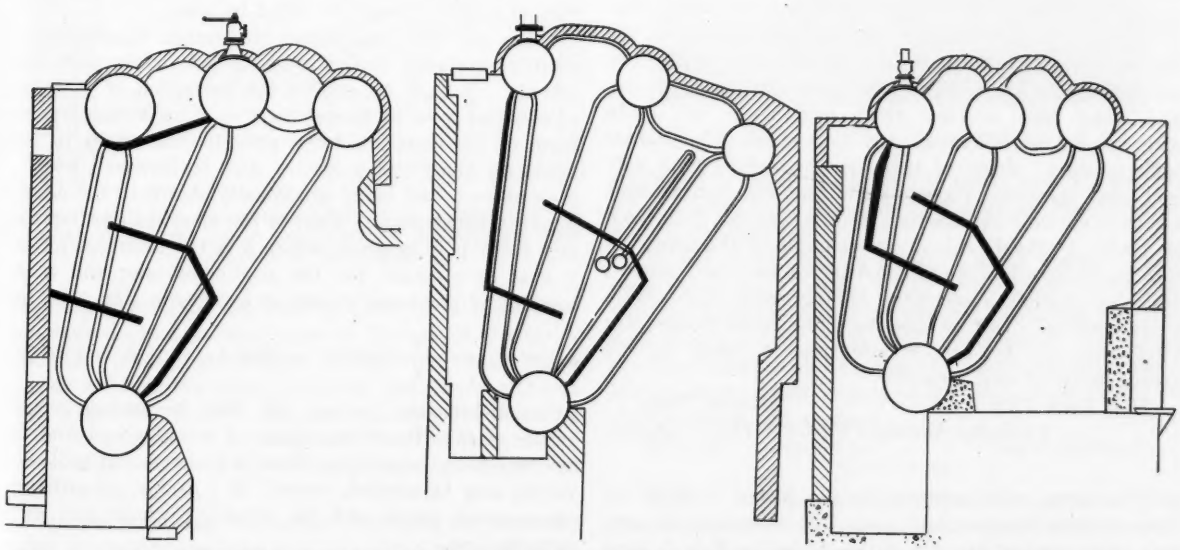


FIG. 2. A. BAFFLING FOR STIRLING BOILER. B. CROSSBAFFLES IN CONNELLY BOILER. C. BAFFLING FOR REVERSED CROSS FLOW ON STIRLING BOILER

Power Specialty Co., who made the soot blower installation, that the operating results at this plant are entirely satisfactory.

It might be well to point out that not only has this particular installation been successful, but it has been followed by a number of others along the same lines, one of which was made in one of the plants of the Anaconda Copper Co., one at the Studebaker Co.'s plant and another at one of the plants of the General Motors Co., all of which are in satisfactory operation.

These additional installations of cross baffles have been in use for a period of over two years and have given satisfaction from standpoints of being kept clean and of boiler efficiency.

Moreover, all these installations have been equipped with soot blowers of standard makes and we have had no report on a failure by any of them to clean the baffles in an entirely satisfactory manner.

It should be noted that the constructional features, as well as those of design, are important, if an installation is to be successful and it was only after completely overcoming earlier objections that it was possible to present the structures shown in these drawings, providing for the easy removal of tubes, as well as the proper supporting of the baffle itself.

Constructive criticisms in connection with any new idea are always acceptable to those who originate and sponsor such ideas but, before presenting such criticisms, reliable information should be secured covering the case in point and the critic should be consistent. We note on page 241 of the Feb. 15 issue of Power Plant Engineering, that the same author shows, in Figs. 2 and 3, boiler baffle designs presented as satisfactory in which the angle of inclination, as he recommends in Feb. 1 issue, is practically absent.

Cleveland, Ohio. A. C. DANKS,
President Ashmead-Danks Co.

IN REGARD to the article by Mr. Schaphorst in the February 1 issue on horizontal baffles, this would seem to create the impression that such baffles would probably be unsatisfactory in a boiler design. This is incorrect since many of the leading horizontal water tube boilers have a horizontal baffle at some point in the design. Successful installations include a 360-hp. Connelly boiler for the General Tire & Rubber Co. at Akron, and many Nelis boilers, which have come into quite wide use for marine work. On these a nearly horizontal baffle is used. Some of them are hand-fired with soft coal, and operating reports show that the performance has been entirely satisfactory with no trouble from lack of draft. Probably this is one example of the many instances where a feature of construction may be rendered desirable though apparently having some undesirable characteristics. In this case the undesirable feature has been overcome by proper attention to detail in the arrangement of soot blowers.

New York City. FRANK PAGE.
Publicity Manager Foster-Wheeler Corp'n.

I NOTICED with interest in the March 1 issue of Power Plant Engineering, page 302, objection of several correspondents to my statement in the Feb. 1 issue that "Soot and ash deposit will not be blown off either by the gas in its natural flow through the boiler or by the steam through soot blower nozzles."

Knowing that I sometimes do make mistakes, I dug into my files for the carbon copy of the article as submitted.

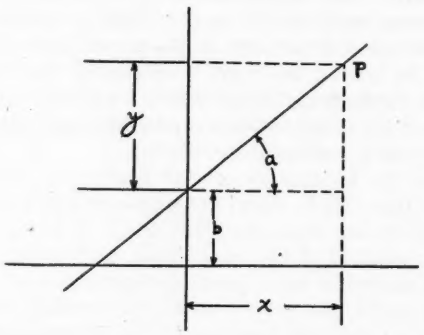
On checking up with the carbon copy of the article as originally submitted, I find that the following are the exact words as I wrote them: "Soot and ashes will refuse to be blown off by either the gas in its natural flow through the boiler or by steam through the soot blower nozzles situated distantly from the baffles."

My critics are right, of course. Where proper provision is made for keeping the baffles clean, they can surely be kept clean. Soot cleaner elements correctly designed and installed will keep the flattest baffles clean. Where you have flat baffles, install a first-class soot cleaner and keep the baffles clean.

Newark, N. J. W. F. SCHAPHORST.

Plotting Equations as Straight Lines

IN A RECENT issue of Power Plant Engineering (page 1197, Oct. 1, 1928) appeared a brief reference to the possibility of plotting the general equation having the



form of $y = x^n$ as a straight line through the use of logarithmic cross-section paper. This is a simple procedure but unfortunately, logarithmic cross-section paper is not always available. Standard cross-section paper can, of course, always be ruled by hand.

It is also true that tables of common logarithms are readily available in engineering handbooks and high schools. If then we extract the logarithm of each side of equation $y = x^n$ we get $\log y = n \log x$; this has the form of the equation for a straight line given in text books on analytical geometry and in Bowser's book as $y = ax - b$ and being graphically shown in the accompanying illustration. That is the equation for locating any point p is as given where b is the intercept on the y axis or constant for the particular case and a the tangent of the angle shown at a or ratio y/x, then tan

$$a \text{ (or } a) = \frac{y}{x} \text{ and } y = \tan a \cdot x;$$

if b is zero the equation becomes $y = ax$. If, then, we assume certain values or take the given values of y and x and find the corresponding logarithms from a common log table the values may be plotted, instead of y and x, on ordinary cross-section paper and the resulting graph will be a straight line.

New York, N. Y. C. O. VON DANNENBERG.

Burner Setting Incorrect; Causes Boiler to Foam

REFERRING to the change made in a boiler setting to prevent foaming by Fred S. Rutledge, page 143 of the January 15 issue, the burner was incorrectly installed

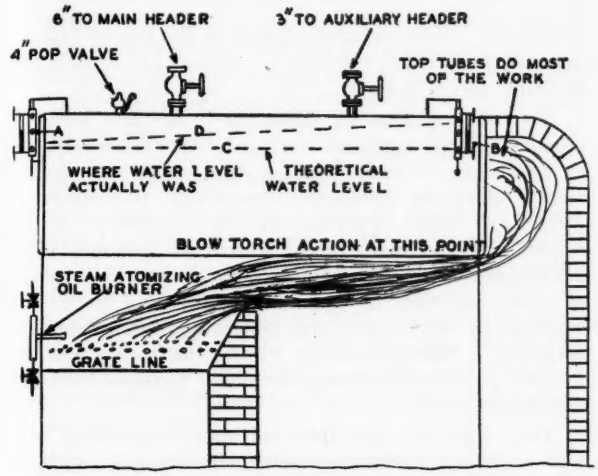


FIG. 1. BLOW TORCH ACTION OF GASES SETS UP INTENSE LOCALIZED HEATING

in the first place. There was no justification for the construction illustrated. Why lose 30 per cent of the available combustion space?

In the original construction shown in Fig. 1, a blow torch action was set up which acted with intensity where the gases were blown against the bottom of the boiler.

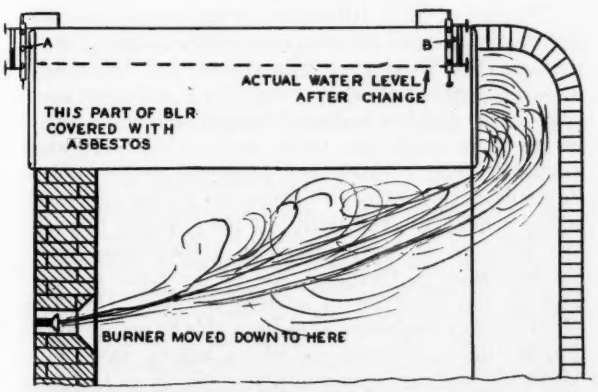


FIG. 2. REMOVAL OF BRIDGEWALL AND LOWERING OF BURNER PROVIDES GOOD COMBUSTION CONDITIONS AND AVOIDS LOCAL HEATING

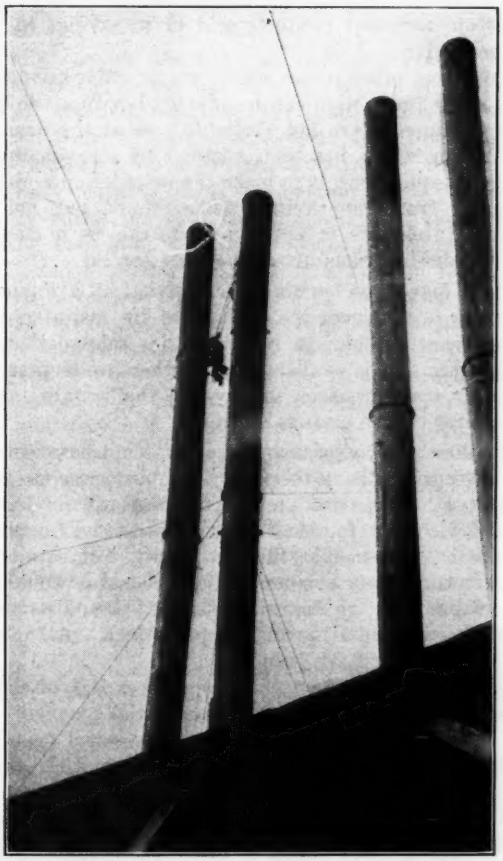
The high velocity of the burning gases in this construction caused them to sweep around the end of the boiler and pass, for the most part, through the upper tubes as shown, hence the upper part did most of the work of heat transmission. By this method, also, the burning gases were forced at once against the cold part of the boiler, thus cooling them during the combustion process and forming smoke.

Instead of taking the burner from the front of the boiler, it should have been merely lowered and the entire bridge wall removed as shown in Fig. 2. This would have provided ample opportunity for complete combustion of the oil and for proper spreading of the current of burning products so that localization of heating of the boiler and cooling of the burning products would have been avoided.

Belleville, N. J. H. H. BAUMGARTNER.

Stack Repair Requires Courage

PROFESSIONAL wall climbers or parachute jumpers always attract admiring audiences and a host of photographers to record their fool-hardiness. But little is ever mentioned of the many industrial workers who are daily



UP HE WENT TO FIX THE CABLE-GUY RING

employed at tasks which require nerve and cool-headedness to supplement the thorough working knowledge of a highly skilled trade.

In the illustration is shown a stack worker, seated on a swing chair, which would be none too comfortable with one's feet touching the ground, adjusting the cable ring near the top of an 80-ft. steel stack. Industrial accident records show that safety cannot be guaranteed. We are always glad to give such fellows much credit for their coolness and courage.

Missouri Valley, Iowa. FRANK BENTLEY.

WHEN A NEW plant or additional equipment is being considered, interest, depreciation, insurance, taxes, overload capacities and efficiency must all be given due consideration.

Editorial Comment

New Equipment Bought from Losses

Investments are made for the purpose of earning interest or profit. When money can be borrowed and put to work so that it yields a return in excess of the interest paid to the lender, both lender and borrower are benefited. The return to the borrower may be in profit on increased products sold or in savings in cost of production.

Instances often occur where worth while savings or increase of production can be effected but funds to purchase equipment are not available just at the moment. A solution, which has been adopted by some manufacturers of equipment, is to make the installation and take payment from the savings which result but not all manufacturers are in position to do this as it may tie up considerable amounts of working capital.

This leaves an opening for activity of a financing company to take over the contract of the manufacturer, thus permitting him to realize on his sale so that his working capital is available for further production and allowing the purchaser to pay for the installation as he realizes on the savings effected.

If the sale of equipment is on a sound basis so that the savings are sure to result, the purchaser gets the benefit, otherwise not possible, of reduced production costs, which pay for the new equipment over a period and, after that, increase his net profit. The equipment manufacturer gets business which otherwise would not materialize and the financing company keeps its funds at work with sound security for the loan. All parties to the transaction are gainers.

In such cases, the purchaser should expect, of course, to pay some part of the cost as an initial payment, and the balance would be taken care of by serial payments over such period as the expected savings make desirable and arranged to cover the cost of equipment, installation and interest on the borrowed money. Evidently, unless the savings will be considerable, so that repayment from them will close the transaction in say three years or less, this method of purchase would not apply even though it might be worth while to make the installation and finance by bond or stock sales. Where applicable, however, the savings payment plan gives opportunity for immediate improvement of plant and production and continuing benefit to the business. It offers a way out to plants in need of rehabilitation.

Delays in Plant Improvement

Two potent causes of delayed plant betterment programs in industrial works are a lack of knowledge of what can actually be accomplished by proposed changes and a lack of confidence in those who support the proposed improvements. No one man can be expected to be an expert in every phase of the industry with which he is connected. The head of any organization must depend upon the services of others to accomplish the desired ends. These services may be in the line of following out definite instructions or in the line of original thinking and planning.

To maintain a power plant up to the last word in economy entails constant study of changing conditions in the field. Developments in equipment and instruments, changing processes throughout an industrial plant may offer opportunities for economies in the power plant; changes in the source of fuel may offer advantages, all these conditions enter into the economy of operation and, as opportunity presents itself, the engineer in charge of power generation will render his employer a valuable service by keeping him posted on desired and necessary improvements recommended for his power plant.

Only a few executives are willing to experiment with new equipment unless they personally are well informed and familiar with equipment of that class. As a result, recommendations must usually be for equipment well beyond the experimental stage, with practical operating data available. Dealing as he does principally with human relations, the executive places more importance on and gives greater attention to the ability and loyalty of his employes than to the equipment that is in their care. To obtain improvements for his department, therefore, the engineer must gain and keep the confidence of his employer.

Because of their differences in experience, men react differently toward authorizing expenditures for improvements. Their mental inertia cannot be overcome, however, without these two conditions, sufficient knowledge of the problem and confidence in the engineer. To create these conditions takes time on the part of the engineer—time to gather and properly present sufficient data and time in which to prove his ability and loyalty to the employer. The ability of the engineer to present the solutions of his problems in a convincing way to his employer, is, therefore, one of the main factors in keeping his plant up to modern economy. With this ability, many engineers have been able to secure authorization for improvements where others have failed. Delays in making improvements are costly and, although usually charged against the management, can be avoided by good engineering.

The Rocket—A New Form of Power Application

Most power plant engineers, when they stop to think about it, know that a large percentage of the total power developed in this country is in various types of engines driving vehicles over the land, on the water and through the air. As a matter of fact, reliable estimates of the total power developed in the country vary between 750,000,000 and 1,000,000,000 hp. of which about two-thirds, it is stated, is in engines, driving automotive vehicles. These engines, mostly

internal combustion machines, are comparatively small in size but are power plants no less than the largest central station.

One application of power that has engaged the attention of few engineers is the rocket. Recent news items and photographs have called attention to experiments with airplanes and automobiles propelled by rockets. But what the general public does not know is that for several years, Professor R. H. Goddard at Clark University and other scientists here and abroad have been experimenting seriously with rockets. These bear little resemblance to the ordinary Fourth of July toys with which most of us are familiar, although they operate on exactly the same principle.

As a heat engine, the rocket is stated to have a thermal efficiency of as much as 50 per cent compared to the 30 to 34 per cent of the Diesel engine. Disposing of the products of combustion is comparatively easy when the rocket is driving a single aircraft or automobile. What might result, if the air were filled with rocket aircraft, discharging large volumes of gas, is open to speculation and the same is true as to rocket-driven cars.

Putting rockets on a wheel to drive it about its axis has been suggested. But here again that problem of the exhaust gases might be hard to solve. Also, the rocket is especially adapted to producing motion of translation rather than rotation. The latter, in a vehicle engine, is produced only as a means to an end. It should be remembered that the rockets in question are, in reality, internal combustion engines in which the piston is projected into space with great velocity by the reaction of the gases. Furthermore, this reaction does not depend on high air pressure but increases as the air thins.

The problem then arises as to whether this flight can be controlled or maintained by successive explosions. Experiments with liquid explosives, admitted under control to the combustion chamber indicate that this is possible.

Moreover, enormous velocities may be attained by these rocket-propelled vehicles. Even since Jules Verne wrote about a trip to the moon in a rocket, mankind has dreamed of conquering space in this manner. It seems now that the rocket offers a possibility of producing a velocity of about 7 mi. a second, high enough to take it clear of the earth's influence. One scientific use has been made of rockets in endeavoring to explore the earth's atmosphere above the points to which men can fly. Several rockets carrying scientific instruments have been sent up and brought down with the instruments uninjured.

This novel phase of power development, the rocket experiments, is now being developed by Professor Goddard and others as a serious and scientific attempt in a little known field. These men are not cranks, harebrained inventors nor charlatans; on the contrary, they are scientists of the highest reputation. Whether, in our time, they will be able to produce rocket engines that will be of practical value is another question. Yet, when some of us think back to the time when there were no telephones, airplanes, radio nor television, we must feel that anything is possible.

Where the Farmer Uses Power

Much remains to be learned about rural electrification, yet the fact remains that it is of primary importance to the majority of our operating companies. It is the only large undeveloped field to which all companies, outside of the few highly industrialized districts, must look for increased load.

For this reason, the results of a study made by the Kentucky Utilities Co., covering a group of farms for which detailed records were kept through an entire year, are of unusual interest. Twelve different applications, ranging from 25 to 1450 kw-hr. per year were covered. The average retail value of electrical equipment per farm was found to be $1244 exclusive of wiring.

Oddly enough, the heaviest loads were found to be ranges, refrigeration and lighting, with a consumption of 1450, 650 and 340 kw-hr. per year. Radio accounted for 80 kw-hr. a year, so that these four items do not differ greatly from urban requirements.

The remaining eight applications were, however, strictly rural, the four most important of these being milking machines, well water systems, motors (3 and 5 hp.) and incubators with 325, 215, 210 and 130 kw-hr. per year, respectively. Remaining load was split up as follows: laundry irons, 45; washing machines, 40; cream separators, 35; and soft water systems, 25 kw-hr. per year or about 300 kw-hr. per month, a substantial load sufficient to indicate the potential importance of this relatively new field. True, rates are high in the average rural district, but increased use will bring them down considerably. For the effect of intensive rural electrification on rates, we may look to the region between Cleveland and Ashtabula, O., served by the Cleveland Electric Illuminating Co. Here intensive development has brought rates to a point where rural and urban rates are the same which is considerably below many, if not the majority, of our cities.

One angle of rural electrification which has been extremely effective in adding new customers is the appeal to the womenfolk. According to a recent issue of the Kentucky Utility News, the advantages of labor saving devices for the farm wife have been summarized by their rural home expert, into five major divisions as follows:

They shorten her hours of labor. The average work-day for farm women is 11.5 hr., and 87 per cent of farm women have no vacations at all. Electric lights alone will give her two days vacation a year as the result of time saved by not having to care for lamps. Laundry and other equipment can cut her work-day to 8 hr.

Electricity reduces the manual labor otherwise necessary and so increases her health and well-being.

Electric service gives the home more beauty and comfort by the use of electric lights, the radio and numerous other appliances.

Health is safeguarded by electric refrigerators and similar equipment, all of which bring the country family to the physical par of the city dweller.

Electric service enables the farm wife to make money. Many women are now operating hatcheries, poultry ranches and similar industries who could not do this otherwise.

Power Plant Engineering Developments and News

Combined Deaerator and Hot Water Generator

COMBINED DEAERATOR and hot water generator, designed to heat and deaerate water for distribution through hot water heating and service systems, has recently been placed on the market. It is intended to reduce the oxygen content of the water to practically zero, to make it possible to use iron or steel piping instead of brass or copper piping and to abolish the red water nuisance.

In the standard deaerating heater, used in steam power plants, exhaust steam or steam bled from the main turbine is allowed to come into direct contact with the water, effecting deaeration without the use of a metallic heat transfer surface. Where water is to be supplied to kitchens, bath rooms, laundries and processes, however, direct contact of exhaust steam with the water is usually undesirable; furthermore, it is preferable to recover for boiler feed purposes the distilled water represented by the condensed steam rather than to allow it to be dissipated in the hot water service system. For this reason, in the combined deaerator and hot water generator heat is transmitted from the heating steam to the water through the metal surfaces of heating coils.

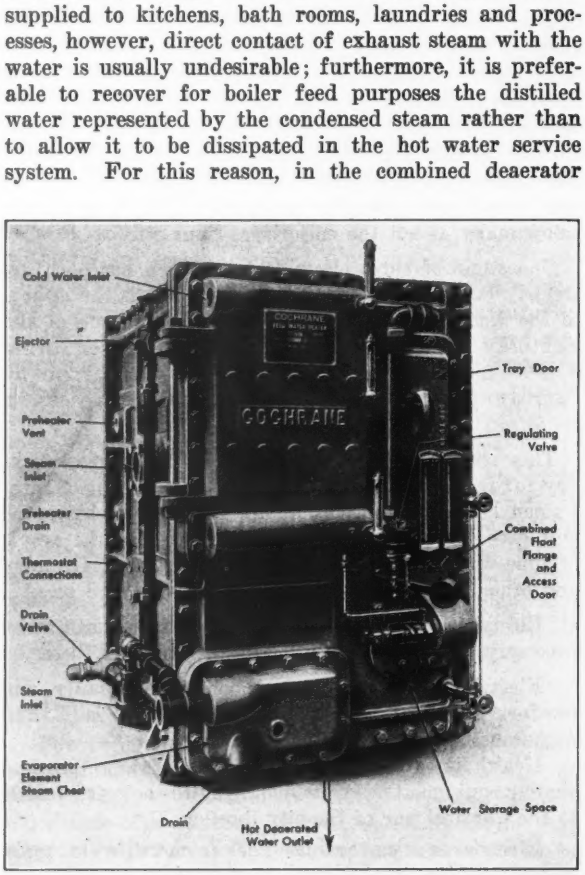


FIG. 1. FITTINGS AND OPENINGS ARE ALL ON FRONT AND ONE SIDE OF COMBINED DEAERATOR AND HOT WATER GENERATOR

Raw cold water first enters the vent condenser, from which it passes through a tubular preheater to the control valve, then flowing onto the deaerating trays in the upper part of the shell, dropping from the latter into the storage space of the heater. Steam enters the preheater through a valve controlled by a thermostat subject to the temperature of the water leaving the preheater. Also, it enters the evaporator coil in the storage space through a valve controlled by a thermostat bulb exposed in the steam space above the water in the storage chamber.

The steam admitted to the evaporator boils the water in the storage space, generating steam which rises through the trays over which the heated incoming water is flowing, completing the heating of the water and sweeping out the gases liberated therefrom. The mixture of air and gases rising from the tray stack passes into the vent condenser where the steam is condensed and its heat recovered by the incoming cold water, while the air escapes through the vent, when the apparatus is operated at 212 deg. or higher, or is drawn out by a vacuum pump or steam jet ejector, where the apparatus is operated at temperatures lower than 212 deg., as is often the case in connection with heating or hot water service systems.

Condensate from the vent condenser drains back into the tray chamber. The preheater and the evaporator are vented directly to atmosphere, the drips therefrom being generally returned to the boiler either by way of a feedwater heater or directly by a returns trap or pump. The preheater, in which most of the heating is done, has three passages for the water so that the water is circulated rapidly, which is advantageous from the point of heat transmission. The function of the evaporator is to reboil a small portion of the water,

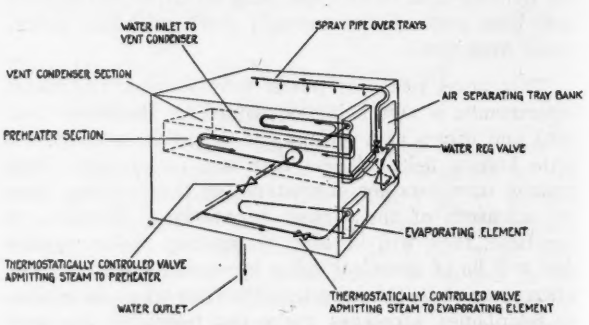

WATER INLET TO VENT CONDENSER
SPRAY PIPE OVER TRAYS
VENT CONDENSER SECTION
AIR SEPARATING TRAY BANK
PREHEATER SECTION
WATER REG VALVE
EVAPORATING ELEMENT
THERMOSTATICALLY CONTROLLED VALVE ADMITTING STEAM TO PREHEATER
WATER OUTLET
THERMOSTATICALLY CONTROLLED VALVE ADMITTING STEAM TO EVAPORATING ELEMENT

FIG. 2. FLOW OF WATER, STEAM AND AIR IN COMBINED DEAERATOR AND HOT WATER GENERATOR

which has a highly deaerating action in itself and also supplies vapor to ventilate or scavenge the space surrounding the water flowing over the trays.

These combined deaerators and hot-water generators are built by The Cochrane Corp., 17th St. and Allegheny Ave., Philadelphia, Pa., for pressures varying from a complete vacuum up to 10 lb. gage and designed to receive water at 40 to 70 deg. F. and deliver it deaerated at 160 to 180 deg. F., using steam at any temperature up to 235 deg.

There is no piping over the front of the heater shell, the connection with the water space to the vent condenser being made in one side plate while the steam connection to the preheater and evaporator steam chests are made through unions at one side, breaking of these unions permitting the cover plate to be thrown back. The top plate, back plate and one side of the heating shell are free of all openings or connections so that the heater may be placed in a corner and up against a ceiling, supported on a single structural foundation. This is to make it suitable for installation in crowded basement engine or boiler rooms and to provide the maximum head upon the suction of the circulating pump.

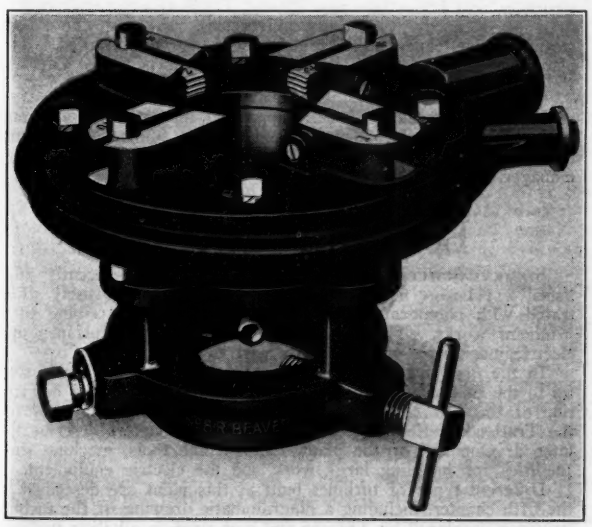
Four Poster Die Stocks for 1 to 2-In. Pipe

BEAVER four-poster, Nos. 8 and 8 R, for threading 1, 1¼, 1½ and 2-in. pipe, has recently been developed, as shown here, by The Borden Co., Warren, Ohio. These tools use a separate set of dies for each size of pipe and are designed with a self-contained rear end, for accuracy and convenience, to obviate the need for bushings and thus to provide rugged construction.

Grip screw is heavily made with a $2\frac{3}{16}$-in. cross pin. The guide bolt is heavy, with grooves for holding the hardened steel washer in the proper size. Die slots are open to permit easy cleaning.

Fully enclosed die-retaining mechanism is provided so that springs will not cut the operator nor be damaged or lost. Extra heavy upright posts, bearing a "standard" mark, are provided, also a ratchet-pawl mechanism of simple and new design.

The No. 8 is the plain and the No. 8 R, as shown, the ratchet die stock.



FOUR-POSTER DIE STOCK

Ljungstrom Horizontal Preheater

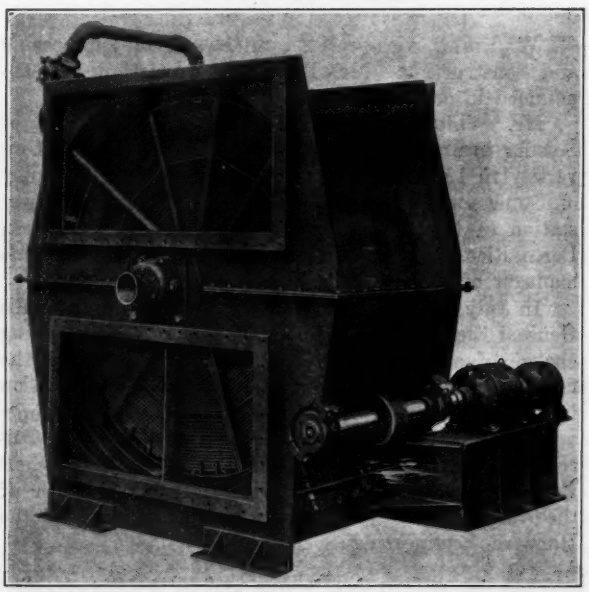
LJUNGSTROM HORIZONTAL air preheater as shown has been introduced for moderate and high temperature work and for applications in which the horizontal operation may permit more desirable equipment layout and effects savings in building construction, ducts and fan foundations.

Many of these horizontal units have been built and placed in service abroad and the decision to introduce the horizontal Ljungstrom type into America was based upon the performance of some 36 installations in Sweden, 28 in Great Britain and others in various foreign countries, which were investigated by the engineers of the Air Preheater Corp., New York.

This horizontal design is built in three classifications, differing in their construction according to the temperature of the entering gas as follows: For initial flue gas entering at temperatures up to 1000 deg. F., built from standard open-hearth steel; for temperatures up to 1200 deg., the casing on the hot end, half the depth of the rotor on the hot end and the heating elements are high-chromium-nickel steel, and the other parts, standard open-hearth steel; and for temperatures up to 1600 deg., built throughout from high-chromium-nickel steel.

The rotor has the usual grouping of Ljungstrom heating elements in cells but with locking straps at the heating element ends to prevent horizontal movement. The rotor drive is similar to that in the ordinary or vertical Ljungstrom preheater.

Two double-row self-alining SKF ball bearings mounted on trunnion extensions of the center post carry



LJUNGSTROM HORIZONTAL PREHEATER, SHOWING ROTOR, TRUNNIONS AND DRIVING MECHANISM

the weight of the rotor. Both center post and trunnions are hollow and form a passage for flow of water which keeps the bearings cool. The bearings are lubricated with heavy grease inserted through Alemite connections.

The housing is split horizontally at the center line and, in the larger sizes, each half is divided into three flanged and bolted parts. The bearing housings are built into the end sections of the housing and their support is strengthened by struts. A combination of peripheral, radial and axial sealing is used to prevent leakage.

The heating elements are cleaned by perforated soot-blowing pipes located in the gas path and placed so that the jets will blow in both directions through the rotor. As the heating elements in each section of the rotor shift slightly with each rotation, dust and fly ash accumulations are continually kept loose and are readily dislodged by the action of the jets.

Herbert S. Whiton, New Byllesby Chief Mechanical Engineer

HERBERT S. WHITON has been appointed acting chief mechanical engineer of Byllesby Engineering & Management Corp. following the resignation of H. Boyd Brydon on March 15, according to an announcement by

H. W. Fuller, vice-president in charge of engineering and construction. Mr. Brydon's resignation was announced in our last issue.

Mr. Whiton received the degree of Bachelor of Science in Mechanical Engineering from Harvard University in 1901. Early in 1905, he entered the employ of Stone and Webster as chief engineer of the power station of the Ponce Railway & Light Co. at Ponce, Porto Rico. At the end of about 2 yr., he was made manager of the company.

In July, 1909, he was transferred to the Minneapolis General Electric Co. as superintendent of power, having charge of all power stations and substations and the maintenance and operation of a 60,000-v. transmission line between St. Croix Falls, Wisconsin, and Minneapolis. In June, 1923, he was transferred to the Chicago office of the Byllesby Engineering & Management Corp. as assistant to Mr. Brydon. He is a member of the American Society of Mechanical Engineers and the Harvard Engineering Society.

NATURAL GAS is extensively used for boiler fuel in the Southwest.

News Notes

PETER JUNKERSFIELD, vice-president of Stone & Webster, died recently at his home in Scarsdale, N. Y. He was 60 years old.

He was born near Sadorus, Ill., and was educated at the University of Illinois. He was employed by the Chicago Edison Company and its successor nearly 24 years, serving at one time as head of the engineering department and later as an assistant vice-president. In 1916 he became president of the Association of Edison Illuminating Companies. During the World War he was engaged in war plant construction, for which he received the Distinguished Service medal.

Surviving him are his widow and two daughters.

E. R. NORRIS HAS been appointed assistant to vice-president according to an announcement issued by J. S. Tritle, vice-president in charge of manufacturing of the Westinghouse Electric & Manufacturing Co. Mr. Norris, formerly General Works manager, will now be responsible for all plant facilities of the company, manufacturing methods, cost reduction and inspection. Mr. Norris has been associated with the Westinghouse Company since 1892.

H. W. CALDWELL & SON Co. of Chicago has announced a new standardized drive for screw conveyors of 8 to 16 in. diameter. It is made in two arrangements. Type C has two speed reductions from motor to conveyor, one a silent chain drive, the other a worm gear, the motor being mounted above the conveyor casing. Type D has the motor on a base plate at the side of the conveyor and a single worm gear speed reduction. All bearings are anti-friction, end thrust being taken by Timken roller-bearings. Conveyor speeds from 45 to 125 r.p.m. are possible with motor speeds of 860 to 1430 r.p.m.

COMBUSTION ENGINEERING CORPORATION, New York, announces the removal of its Hazleton, Pa., representative, the Coxe Stoker Engineering Co., to new quarters, Room 1109 to 1114 Markle Bank Building.

E. G. ALLEN, FORMERLY ADVERTISING representative at the South Philadelphia Works of the Westinghouse Electric & Manufacturing Co., has resigned his position to assume charge of Advertising at the Fuller-Lehigh Co., Fullerton, Pa., effective March 3, 1930. Mr. Allen, a graduate mechanical engineer, became identified with the Westinghouse Company in 1920, starting as Stoker engineer, later transferring from that Department to the Sales organization. In 1926, at the time the Advertising Department was organized at the South Philadelphia Works, Mr. Allen was selected to head that activity.

THE BRADY CONVEYOR CORP., 20 West Jackson Blvd., Chicago, Ill., has taken over the sales and manufacturing rights of the Universal Coal Spreader Co.

PENNSYLVANIA PUMP & COMPRESSOR Co., Easton, Pa., has appointed the Kring-Becker Engineering Co., Mercantile Library Bldg., Cincinnati, Ohio, as its representatives in the Cincinnati and Louisville districts.

THE ROBERTSON PAPER BOX Co., INC., of Montville, Conn., has started construction of a new boiler plant addition at its Montville plant. The structure, to be of modern fireproof construction, will house two new 200-hp. HRT International boilers fired by Kennedy Van Saun pulverizers. A new Lee 90-hp. steam turbine paper machine drive will also be installed. The plant was designed and is under the supervision of Carl A. Lefen, Inc., New York City.

H. M. HAMMOND has been appointed manager of sales and engineering of Bailey Meter Co., Cleveland, Ohio. Mr. Hammond's former position with the company was that of sales manager.

Books and Catalogs

SIEMENS-SCHUCKERTWERKE A. G., Berlin, have recently published a 111-page book printed in Germany and profusely illustrated with photographs, drawings and sketches describing their Mulheim works. This factory, devoted to steam turbines and electric machinery, was originally part of the Thyssen Co.

In the first chapter, the original Thyssen plant and its history up to the time of the transfer are given, together with a description of the first 22,500-kw., 3000-r.p.m. turbine built in 1924 for the Trattendorf Central Station. Following chapters describe the later development of the plant, the machine tools, machine shop facilities for handling large work and the electric equipment.

Different types of turbines built at this plant are described in the fifth chapter, including a diagrammatic drawing of the turbine governor developed by Thyssen and now used on all their turbines because of its excellent design and performance.

COOPER-BESSEMER GAS AND OIL ENGINES are described in several attractive bulletins, published by the Cooper-Bessemer Corp., Mt. Vernon, Ohio. One of these shows all the types of engines made by this organization. Another 12-page bulletin shows in detail the Type-80 Cooper gas engine compressor, single cylinder, 85 br-hp., twin cylinder, 170 br-hp. This is a four-cycle, horizontal, single-acting, direct-drive unit. The Type 16 compressor unit, a four-cycle, 50-hp., direct-drive convertible gas or Diesel engine is described in detail with installation photographs and layout drawings in another 18-page bulletin. Vertical gas engines of various capacities are discussed in an 18-page bulletin, with many illustrations of the parts of the engine and of actual installation.

DIVISIONS AND PRICE LIST of the Engineering Index Service carried on by The American Society of Mechanical Engineers, 29 West 39th St., New York City, are given in a recent bulletin issued by the Society, copies of which may be obtained from the secretary.

QUALITY ENGINEERING is the title of a rather unusual bulletin just issued by American Hoist & Derrick Co., St. Paul, Minn. This is an 18-page bulletin, illustrated entirely in colors, showing various types of cranes, derricks and hoists made by the company.

MODERN REFRACTORY PRACTICE is the title of a 178-page book recently issued by Harbison-Walker Refractories Co., Pittsburgh, Pa. It is attractively bound in cloth, the typography and illustrations are splendidly carried out and the book constitutes a real text on the subject of refractories. The first part of the book describes in detail, with many illustrations, the method of making refractories, shows the special shapes that can be obtained and discusses the many varieties. A section is devoted to high-temperature cements with details of how they are applied. Another section describes the use of Duro acid-proof brick and tile. The last half of the book shows by illustration and text the applications of the product in furnace construction, for boilers, industrial furnaces, kilns, gas works and similar installations. A final section gives formulas for calculating brickwork and for design of arches.

IN ADDITION TO ITS regular line of single-stage, double-suction centrifugal pumps, Pennsylvania Pump & Compressor Co., Easton, Pa., is offering ball-bearing type pumps suitable for capacities up to 1800 g.p.m. against 300 ft. head. These are described in catalog No. 214 recently issued by the company.

CABLE INSTALLATION, publication No. 02 of the Underground Systems Committee, Engineering National Section, National Electric Light Association, 420 Lexington Ave., New York City, has just been issued. This describes various methods of installing cable in underground conduit systems in suburban sections with reduced capital expenditures. New practices or equipment used in underground cable and additional information on duct lubrication and pulling stresses, are included. Cable reel standards, as adopted by the Insulated Power Cable Engineers Association and approved by the Underground Systems Committee is given for reference, as is also a summary of reports from member companies on the re-use of withdrawn cable.

CONSTRUCTION AND MAINTENANCE Equipment and Methods, Publication No. 08 of the Overhead Systems Committee, discusses labor-saving devices, methods of construction and new equipment used for pole line construction and maintenance in the electric light and power industry. A series of illustrations shows more refinement in designs for particular applications in truck work. The use of a narrow gage railway for construction of a tower line through swamp land and a blasting method of setting poles in boggy ground are described and illustrated.

OPERATING METHODS, OVERHEAD and Underground Primary and Secondary Distribution Systems, Publication No. 03 of the Overhead Systems Committee, discusses the best practice in operating methods of overhead and underground primary and secondary distribution systems. The data are based on replies to two comprehensive questionnaires: the first dealing with operation of the overhead distribution feeders, including primary and secondary systems and transformers; and the second questionnaire on the operation of the underground distribution feeders, also including primary and secondary systems and transformers. All figures and conclusions relative to underground practice are based on the analysis of communications received from 31 operating companies. Data on the overhead distribution systems are based on replies of 39 companies.

BRISTOL'S RECORDING PRESSURE and Vacuum Gauges are described in detail in a loose leaf bulletin published by the Bristol Co., Waterbury, Conn. Details of charts are given, interior construction of the recording gages for pressure and vacuum are described and illustrated and complete description is given of flexible connections and other accessories.

PUBLICATION NO. 015 HAS JUST been issued as a report of the Industrial Relations Committee, Public Relations National Section, National Electric Light Assn., 420 Lexington Ave., New York, N. Y. Public Contact Training is discussed under the following four general headings: 1. Why is a public-contact training program necessary in the electric utility business? 2. What has been done in the field by member companies? 3. What are some of the fundamental principles which should be considered in such a program? 4. Just what steps are necessary in setting up and conducting such a program in an operating organization? Four papers presented at the Industrial Relations Committee's Conference showing practice and experience of Member Companies are given in the appendices.

SYMPOSIUM ON PHYSICAL Properties of Cast Iron, held at the Thirty-second Annual Meeting of the American Society for Testing Materials, June, 1929, has recently been issued by the Society which has headquarters at 1315 Spruce St., Philadelphia, Pa., R. E. Hess, Assistant Secretary. The Symposium took up classification of gray iron alloys, effect of section and various compositions, static strength of plain and alloy cast iron, elastic properties, impact testing, wear testing, machineability, corrosion and heat treatment. This collection of papers contains a great deal of authoritative data on cast iron, including much valuable material brought out in the discussion of the papers.

AUTOMATIC MAGNETIC-REVERSING printing-press controllers with dynamic braking for d.c. motors, are described in bulletin No. 115 by Monitor Controller Co., Baltimore, Md.

STANDARDIZING COMBUSTION Practice is discussed by the Hays Corp., East 8th St., Michigan City, Ind., a recent 20-page bulletin. This describes Hays draft gages, shows how they are constructed and discusses the ways in which they may be used to increase boiler efficiency and reduce cost. Various types of single and multi-pointer gages of the dial and edgewise type are described and illustrated.

VERTICAL DUPLEX COMPRESSORS of the single acting type are described in detail and illustrated in a recent 8-page bulletin by Chicago Pneumatic Tool Co., 6 East 44th St., New York City. Construction of the parts is treated in detail, and the compressor is shown with various types of drives.

STEEL MIXTURE FURNACE LININGS and Arches are described in catalog No. 52 by McLeod & Henry Co., Troy, N. Y. The bulletin discusses first, boiler door arches and jambs and boiler settings, then shows types of fire box blocks, blowoff pipe protectors and finally discusses veneer walls, air-cooled furnace walls, suspended walls and suspended arches, together with carbex refractories for use at extremely high temperatures.

BARCO LUBRICATED PLUG Valves for air, gas, gasoline, oil, steam, water, tar and other fluids, are described in catalog 313 by Barco Manufacturing Co., 1801 Winnemac Ave., Chicago, Ill.

MECHANICAL RESULTS FROM Hand Stokers is the title of an 8-page illustrated bulletin, issued by McClave-Brooks Co., Scranton, Pa. It describes the McClave hand-fired stokers in detail with illustrations of parts and assemblies.

MECHANICAL-DRIVE TURBINES are covered by Bulletin GEA-1145, just issued by General Electric Co., Schenectady, N. Y. This gives details and the construction of the various types of machines and shows how they are used for driving pumps, stokers, fans and other power plant equipment.

IN BULLETIN GEA-77G, the company discusses in detail capacitors for power factor correction. Calculations for determining the proper capacity of this equipment are shown and the theory and method of use of the capacitor is also discussed in detail.

IN BULLETIN NO. 101 just issued, Hall Laboratories, Inc., Pittsburgh, Pa., announces a new chemical for boiler water conditioning. This consists of phosphate in the tri-, di-, and monosodium phosphate forms, depending upon the conditions encountered.

THE FLOW OF WATER in Riveted Steel and Analogous Pipes, a paper by Fred C. Scobey, Senior Irrigation Engineer, Division of Agricultural Engineering, Bureau of Public Roads, has just been issued as technical bulletin No. 150, by United States Department of Agriculture, Washington, D. C. Price 30 cents. The discussion is concerned mostly with pipes of riveted steel and the laws developed for the flow of water in them applies equally well whether the water is used for irrigation, power or domestic use.

TEXROPE DRIVES ARE DESCRIBED in detail in two well-illustrated bulletins just issued by Allis-Chalmers Mfg. Co., Texrope Division, Milwaukee, Wis. Bulletin 1236-A discusses the Texrope drive as a machine-tool drive, showing by photograph the many ways in which it has been applied to all types of this equipment. Bulletin 1228-K shows how the drive has been applied to conveyors, crushers, shafting, laundry equipment, fans, textile machinery, refrigerating equipment and other industrial apparatus.

Power Plant Construction News

Ark., Conway—The Conway Cotton Oil Co., is said to be planning the installation of electric power equipment in connection with proposed rebuilding of portion of mill, recently destroyed by fire with loss reported at $75,000.

Calif., Los Angeles—The Pacific Iron & Steel Co., 241 West Avenue Twenty-six, plans installation of electric power equipment in proposed new plant unit on the Alameda Boulevard, entire project to cost over $100,000.

Conn., South Norwalk—Hain Brothers, Railroad Yard, is planning the construction of a one and two-story ice-manufacturing plant to cost about $60,000. Harry Koerner, Bridgeport, is architect.

Conn., West Haven—The Hygenic Ice Corporation, 881 State Street, New Haven, has authorized the immediate construction of a one-story ice-manufacturing plant at West Haven, reported to cost close to $50,000, with equipment.

Ga., Rome—The Stivers Milling Co., Rome, plans installation of electric power equipment in proposed new flour mill to cost over $150,000.

Ill., Chicago—The Perfection Parlor Furniture Co., North Avenue, plans installation of electric power equipment in new three-story factory unit at Grove and North Avenues, reported to cost about $80,000. A. A. Tocha, 1200 North Ashland Avenue, is architect.

Ind., Muncie—The Board of Directors, Indiana State Normal School, Indianapolis, Ind., is said to be planning construction of a power plant at the State Normal School, Muncie, to cost close to $50,000, with equipment.

Iowa, Mount Pleasant—The Mount Pleasant Electric Light & Water Works, City Hall, are planning extensions and improvements in municipal electric light and power plant, reported to cost about $35,000. W. F. Weibley, Tama Building, Burlington, Iowa, is architect.

Ky., Bowling Green—The Kentucky-Tennessee Light & Power Co., Bowling Green, is reported planning early construction of first unit of new steam-operated electric generating plant on the Barren River, near Bowling Green, to cost more than $1,000,000, with transmission system.

Md., Baltimore—The Rustless Iron Corporation of America, Inc., Loneys Lane, plans installation of electric power equipment in connection with an expansion and improvement program at local mill, reported to cost over $1,000,000.

Mass., Cambridge—The Cambridge Electric Light Co., Cambridge, has taken out a permit for extensions and betterments in electric light and power plant to cost approximately $200,000.

Mass., Cambridge—The General Radio Corporation, 30 State Street, plans installation of electric power equipment in proposed new plant addition to cost about $85,000. Lockwood, Greene Engineers, Inc., 24 Federal Street, Boston, is architect and engineer.

Mass., South Everett—The Merrimac Chemical Co., plans installation of electric power equipment in connection with proposed rebuilding of portion of plant destroyed by fire March 14, with loss reported in excess of $200,000.

Mich., Allegan—The City Council is said to be planning a call for bids early in April for proposed municipal hydroelectric power plant and power dam to cost $450,000. Ayres, Lewis, Morris & May, Cornwall Building, Ann Arbor, Mich., are engineers.

Miss., Yazoo City—The City Council is said to be planning a municipal electric lighting plant to cost about $75,000.

Mo., St. Louis—The Board of Education, 911 Locust Street, has plans under way for a central power plant for school service, on School Street, estimated to cost about $150,000, with equipment. G. W. Sanger, address noted, is architect.

Mont., Ekalaka—The Common Council is said to be planning the installation of a municipal electric lighting plant, for which estimates of cost will soon be made.

N. C., Asheboro—The Bossong Hosiery Mills, Inc., plan installation of electric power equipment in proposed addition to plant, reported to cost close to $100,000. Lockwood-Greene Engineers, Inc., Charlotte, N. C., is architect and engineer.

N. J., Gibbsboro—John Lucas & Co., Inc., 322 Race Street, Philadelphia, Pa., is said to be planning rebuilding of portion of paint factory, including power house at Gibbsboro, recently destroyed by fire with loss reported in excess of $150,000.

N. J., Sewaren—The Shell Eastern Petroleum Products, Inc., 122 East Forty-second Street, New York, plans installation of electric power equipment in proposed new oil refining plant at Sewaren, entire project to cost about $700,000.

N. Y., Syracuse—The Syracuse Cold Storage Co., Northwest and Tracy Streets, plans rebuilding of portion of cold storage plant "A", recently destroyed by fire with loss reported in excess of $100,000.

N. Y., Troy—The Niagara Hudson Power Corporation, Troy, will carry out an expansion and improvement program at local gas plant, including installation of coke ovens, gas-cooling system, and other equipment, entire project reported to cost over $750,000.

Ohio, Cleveland—The Sun Oil Co., 1608 Walnut Street, Philadelphia, Pa., plans installation of electric power equipment, pumping machinery, steel tanks, etc., at proposed storage and distributing plant at Cleveland, Ohio, entire project reported to cost over $1,000,000.

Ohio, Toledo—The National Milling Co., Toledo, a subsidiary of the National Biscuit Co., 85 Ninth Avenue, New York, plans installation of electric power equipment in proposed addition to flour mill, reported to cost more than $450.000.

Okla., Stilwell—The Common Council is said to be planning extensions and improvements in municipal power plant, including installation of a Diesel oil engine and auxiliary equipment.

Ore., Grants Pass—The California Oregon Power Co., Medford, Ore., is said to be planning a new power substation at Grants Pass, reported to cost more than $60,000, with equipment. The company is also said to be planning an addition to power substation at Klamath Falls.

Pa., Donora—The American Steel & Wire Co., Cleveland, Ohio, will install electric power equipment in proposed new addition to mill at Donora, entire project to cost more than $2,000,000.

Pa., Titusville—The Titusville Iron Works, Inc., plans installation of electric power equipment in proposed one and two-story addition to mill, entire project to cost more than $150,000.

Pa., Wernersville—The Department of Property and Supplies, State House, Harrisburg, will receive bids until April 9, for an electric generating unit for the State Hospital at Wernersville. Also, until April 16, for an electric generator, steam turbine unit, coal-handling equipment, etc., for the State Hospital at Danville.

R. I., Woonsocket—The National Service Co., 150 Congress Street, Boston, Mass., has approved plans for an ice-manufacturing plant at Woonsocket, reported to cost more than $50,000, with equipment.

Tenn., Memphis—The De Sota Paint & Varnish Co., Memphis, plans installation of electric power equipment in connection with proposed expansions and improvements in factory to cost about $100,000. The company is operated by Sears, Roebuck & Co., Arthington and Homan Streets, Chicago, Ill.

Texas, Dahlhart—The West Texas Utilities Co., Abilene, is said to be planning early construction of an ice-manufacturing plant at Dahlhart, to cost more than $100,000, with equipment.

Texas, Midland—The Texas Potash Corporation, 2424 South Boulevard, Dallas, Homer R. Mitchell, president, plans installation of electric power equipment in proposed potash refining plant and development of potash deposits at Midland, entire project reported to cost over $1,000,000.

Va., Roanoke—The Norfolk Western Railway Co., Roanoke, plans installation of electric power equipment in proposed mechanical and blacksmith shop at local repair works, estimated to cost about $200,000.

Wash., Seattle—The Liquid Carbonic Co., 3100 South Kedzie Avenue, Chicago, Ill., plan installation of electric power equipment in proposed dry ice and carbonic gas manufacturing plant at Hudson and Colorado Sts., Seattle, entire project to cost $250,000.